

Author's Copy

VOLUME 6

OCTOBER 1935

NUMBER 5

Sinensia

Contributions

From The

National Research Institute Of Biology

ACADEMIA SINICA

CONTENTS

Pages 551-645

STUDIES ON THE FRESHWATER ALGAE OF CHINA

I

ZYGNEMATACEAE FROM SZECHWAN

中國淡水藻類之研究一，四川之星綠藻科

CHIN-CHIH JAO

饒 欽 止

PUBLISHED BI-MONTHLY BY THE INSTITUTE

ann. arb.
1935



STUDIES ON THE FRESHWATER ALGAE OF CHINA

I

ZYGNEMATACEAE FROM SZECHWAN

A THESIS
IN BOTANY

presented to the Faculty of the Graduate School of the
University of Michigan in partial fulfillment
of the requirements for the degree
of Doctor of Philosophy

CHIN-CHIH JAO

Reprinted from Sinensia
Vol. 6, No. 5, October, 1935

Nanking
1935



STUDIES ON THE FRESHWATER ALGAE OF CHINA

I

ZYGNEMATACEAE FROM SZECHWAN*

CHIN-CHIH JAO

Introduction

The present investigation deals only with the Zygnemataceae of Szechwan, West China, including both known and several new species. The writer plans to report on other families of algae later. The plants described in this paper probably do not include all the species of this family in Szechwan. However, since nearly two thousand collections have been made during several years and in various seasons, and since climate, soils and other environmental factors are quite uniform throughout eastern Szechwan, further collections probably would not yield many other species. Also an algal flora is unlike a phanerogamic flora in that each species is likely to be more widely distributed throughout a large area.

An interesting point in this study is that more than half of the species treated have never been found before. Of course the algal flora of this region has never been reported before, and if one were to make careful studies and collections of this family from any other similar large new area he most likely would discover as great a number of new and interesting forms.

In this paper an attempt is made not only to report the interesting or new species to the professional phycologist but also to give the beginner who wishes to work on the Zygnemataceae in China a usable manual. For this reason, characters used for generic and specific identification, working keys and

*Papers from the Department of Botany and Herbarium of the University of Michigan, No. 541.

a full description and drawings of each species are included. It is considered that much of the taxonomic material here presented will be applicable throughout a large part of temperate China.

This work was carried out in the Botanical Department, University of Michigan, Ann Arbor, Michigan and the Marine Biological Laboratory, Woods Hole, Massachusetts under the direction of Professor Wm. R. Taylor, to whom the writer is deeply grateful for help and advice; the writer wishes, also, to thank Professor E. N. Transeau for useful suggestions and the use of his mimeographed keys to the Zygnemataceae, which were most helpful; furthermore Mr. P. C. Chen, Miss Chun Jao and Mrs T. J. Lung, for their kindness in collecting specimens.

Localities and Materials

The species described in this paper were collected from various stations in three districts of East Szechwan, *viz.*, Pa Hsien (巴縣), Chiangpei Hsien (江北縣), and Hochwan Hsien (合川縣), from 1928 to 1934. The collections were mostly made in winter and early spring from the rice farms or water-storage pools after rice harvest and before the fields have been plowed. After plowing, and during the luxuriant growth of rice in the warm months, the algae, especially the filamentous Chlorophyceae, are in poor condition for study.

Chungking, the chief city of Pa Hsien, is located at 29° 34' N. L., 106° 31' E. L, and stands at an altitude of 230 meters; three sides are bordered by the Yangtze and Chialing Rivers. The city of Chiangpei is located on the northern shore of Chialing River opposite Chungking. The city of Hochwan is on the west shore of Chialing River sixty four miles northwestward from Chungking. The climate, topography, soil and the condition of the fields are quite similar in each locality. The rainy seasons are usually from the end of April to the end of June and in September and October. The annual temperature range, except in the higher mountains, is from 9.2° to 29.1° C, rarely below -1° C in January; frost is exceedingly rare and so is the very thin ice which may appear at times during the night. Sunshine is rare in winter, for a bank of mist hangs over the

land preventing surface evaporation and consequent lower temperatures. This condition makes the soil very damp, keeps even very shallow bodies of water from drying up, and gives very favorable conditions for algae growth.

Eastern Szechwan has been called the "Red Basin", from thick surface layer of red and grey or yellow sandstones. Soils of this area were carried down by erosion from the slowly disintegrating mountains. They are underlain by layers of coal and lime deposits. The surface soil is light in texture and the subsoils are very heavy clay loams. These soils are very favorable for crops and also give rise to satisfactory conditions for the Zygnemataceae.

The stations which have yielded fruiting Zygnemataceae are mostly rice farms or muddy waterstorage pools, and may be listed as follows:

I. Pa Hsien:

1. Ta-Ch'i-Kou (大溪溝), about five miles northwestward from Chungking.
2. Niu-Kioh-To (牛角沱) and Tseng-Chia-Yen (曾家岩), about five and half miles northwestward from Chungking, adjoining Ta-Ch'i-Kou.
3. Li-Tze-Pa (李子壩), a level district bordering Chialing River, about six miles westward from Chungking.
4. Sha-P'in-Pa (沙平壩), a level district near Chialing River, about fourteen miles westward from Chungking.
5. Lung-Yin-Ch'ang (龍隱場), a big market town bordering the chialing River, about fifteen miles westward from Chungking. Formerly known as Tzü-Chi-Kou (瓷器口).
6. Hsiao-Lung-Kan (小龍坎), a small market town, about twelve miles westward from Chungking.
7. Fou-Tu-Kuan (浮圖關), a fortified village on the top of a hill, five miles westward from Chungking.
8. Shih-Chiao-Ch'ang (石橋場), a market town, five miles westward from Fou-Tu-Kuan.
9. Liu-Tien-Tze (六店子), a small town, four miles westward from Fou-Tu-Kuan.
10. Shao-Chia-Wan (邵家灣), about one mile westward from Liu-Tien-Tze.

11. Nan-Shan (南山), a mountain bordering the Yangtze River, opposite to Chungking.

12. T'u-Chiao-Ch'ang (土橋場), a market town, about fifteen miles southwestward from Chungking.

13. Wen-Chuan-Ch'ang (溫泉場), a market town, also a district park, "Wen-Chuan Park" or "Hot Spring Park", located in a valley, about twenty miles southwestward from Chungking.

II. Chiangpei Hsien:

1. Liu-Chia-T'an (劉家堂), the south-western suburb of Chiangpei City.

2. Hsian-Kuo-Shih (香國寺), about six miles westward from Chiangpei City.

III. Hochwan Hsien: The material was collected only from the farms and pools beside the Chialing River near the city.

All the collections were preserved in the following solutions:

Commercial Formalin	4.0 c.c.
Glycerin	10.0 c.c.
Cupric Acetate	0.5 g.
Distilled water	84.0 c.c.

Characteristics used for Identification

Many species of Zygnemataceae are quite similar in their vegetative or young fruiting stages, and therefore identification must be based upon the mature condition of the fruiting filaments only. In their usual condition, the mature fruiting filaments are indicated by having thick, layered and colored spores with the contained chromatophore or chromatophores more or less invisible or confused. On the other hand, if the spores have only thin, one-layered and colorless walls with the green chromatophore or chromatophores quite visible, the fruiting filaments are immature. In the second condition, the material is not satisfactory for specific identification. Only a few species, such as *Mougeotia quadrangulata* Hassall, *M. rotundangulata* Jao, *M. virescens* (Hassall) Borge, etc, have the spores colorless at maturity; most have the spores yellow, yellowish brown, brown or blue in color, excepting the epispore and endospore.

The mature fruiting filaments of certain species were scattered among other algae or only a part of the filaments in a collection were mature. Under these conditions, a dissecting microscope was very helpful when used to select good specimens.

The characters used for generic or specific distinction are described in the following paragraphs. To certain structures terms are applied in different ways by some authors, especially the marking of the spore wall. It seems desirable to describe in detail and draw diagrams of the important characters for beginners studying this family, as has been done.

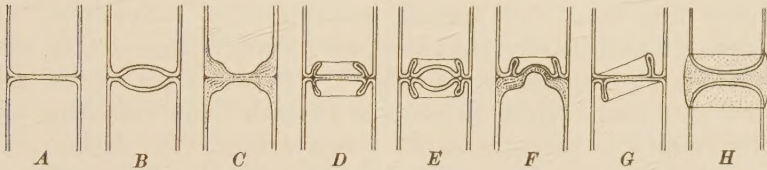


Fig. 1.—Types of End Walls. A—C, plane; D—F, replicate; G, semireplicate; H, colligate. A, D, G and H, showing the typical forms; the remainder showing the variations.

Vegetative cells.—Many phycologists give only the diameters of vegetative cells or just mention their length in multiples of their diameter. Certainly the length of vegetative cells is quite variable, but sometimes it also is helpful for identification. Therefore, the measurements are better given exactly of both diameter and length; of the diameter it is better to measure at the cross walls between cells, especially in conjugating filaments.

Usually the end walls of the cells are simply *plane* (Fig. 1, A—C). Several species of *Spirogyra* have the end walls *replicate* (Fig. 1, D—F), *semireplicate* (Fig. 1, G) or *colligate* (Fig. 1, H). The replicate types have the middle lamella of the septum expanded to form a circular infold over which the subsequent opposition-layers are deposited, a distinct H-piece if seen in lateral view, usually on both sides or occasionally on one side of the end wall of all or part of the cells. The semireplicate end walls have an infold extending only half-way around the division wall which alternates in position in adjoin-

ing cells. The colligate end walls are rare, with an H-shaped (in lateral view) piece between adjoining cells. This structure also is found in other genera, such as *Zygogonium ericetorum* Kützing.

The chromatophores are essentially of five types in this family. *Mougeotia*, *Debarya*, *Temnogametum* and *Mougeotiopsis* have a single axial *platelike chromatophore* (Fig. 2, D, E), nearly as broad as the cell and usually nearly as long as the cell or only, occupying a part of the cell, with or without (*Mougeotiopsis*) *pyrenoids*. The arrangement (scattered or in a single row) and the number of the pyrenoids in a single cell are also important for specific determination. *Zygnema*, and *Zygnemopsis* ordinarily have two, rarely more than two in some cells, *stellate chromatophores* (Fig. 2, C), each with a prominent central pyrenoid, which lie co-axial to each other on either side of the nucleus, rarely located transversely. In *Zygogonium* there are a few species having one or two irregularly *spherical chromatophores* (Fig. 2, B), each with a central pyrenoid, and without or sometimes with very short processes. *Pleurodiscus* has two *disc-shaped chromatophores* in each cell (Fig. 2, A), each containing a central pyrenoid. *Spirogyra* and *Sirogonium* have parietal, spiral or nearly straight, *ribbon-like chromatophores* (Fig. 2, F, G), from one to sixteen in number, each containing a single row of pyrenoids. In these two genera, the number of chromatophores and the number of turns are constant within certain limits for a given species.

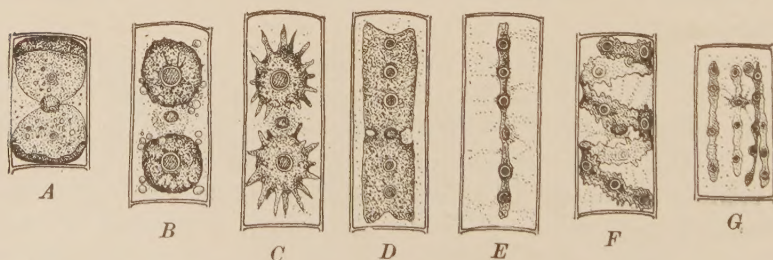


Fig. 2.—Types of Chromatophores. A, disc-shaped; B, irregularly spherical; C, stellate; D and E, plate-like, D in face view, E in edge view; F, spiral, ribbon-like; G, straight, ribbon-like.

The vegetative filaments are typically unbranched. The short branches of one to several cells are occasionally met with in certain species. This is an abnormal condition, not constantly found in a given species. The outgrowth of vegetative cells in the form of rhizoid-shaped or hapteron-formed extensions are rather common, also being constantly found in certain species.

Reproduction.—Four kinds of spore-formation are exhibited: (1) Reproduction by conjugation with *zygospores* formed by *isogamous* or *heterogamous gametes*. Conjugation in this family involves two cells in the same or different filaments. A short tube is formed by one of or both of the *gametangia*, connecting them. This tube becomes opened by solution of the end wall, and then one of the gametes moves over toward the other, which remains in its gametangium or else both move from the gametangia to meet and fuse in the tube. The conjugation process takes place between two filaments, *scalariform conjugation* (Fig. 3, A—H), or between two adjoining cells, *lateral conjugation* (Fig. 3, I). The *conjugation tubes* are either formed by the male gametangium only (Fig. 3, F), or by both male and female cells (Fig. 3, A—E). The *fertile cells* (female gametangia) are usually *cylindrical* in form (Fig. 3, A), but sometimes *enlarged* by pressure of the zygospores (Fig. 3, B) or *inflated* loosely containing the zygospores (Fig. 3, C). the inflated or enlarged fertile cells are usually equally swollen on both sides to produce a fusiform shape, but in certain species they are swollen either on the conjugating side or outer side only (Fig. 3, D, E). A few species have the fertile cells tumid more or less uniformly, resulting in the cell to assume the form called *cylindrical* (Fig. 3, F). The zygospores are either formed in the gametangia, in the conjugation tubes, or in the conjugation tubes with addition of the *sporangial wall* (Fig. 3, G—I). As in *Zygonium*, the sporangial wall is a secondary product which is an independent thin membrane secreted by the gamete and, after the sporangial walls are formed, each gamete may become completely surrounded by these walls; later on, the adjoining walls between the two gametes disappear and the two gametes fuse (Pl. II, Fig. 19). In some species after the fusion of the

gametes, these membranes are reported to become the outermost layer of the spore wall, but in some others they enclose the zygosporcs loosely. In *Mougeotia*, the zygosporcs are either entirely within the conjugation tubes, with two walls separating them from the gametangia, when they are said to be "adjoined

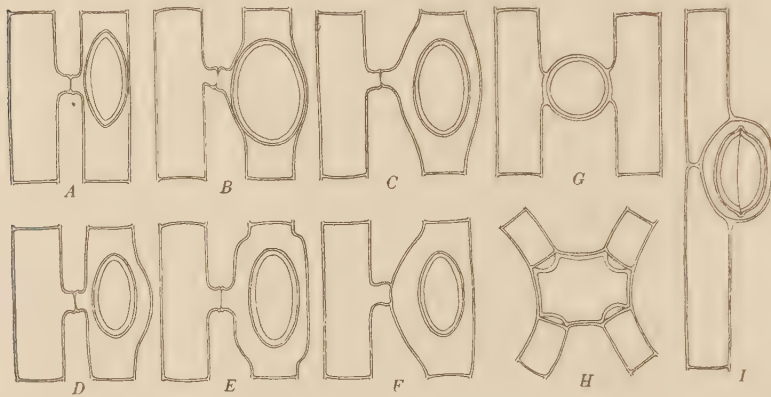


Fig. 3.—Types of Fruiting Cells. A—F, female gametangia enclosing zygosporc, the shape being: A, cylindrical; B, enlarged by pressure of the zygosporc; C, inflated on both sides; D, inflated on the outer side; E, cylindrically inflated, F, inflated on the conjugating side and the conjugation tube formed by the male gametangium only. G—I, zygosporcs formed in the conjugation tube only (G, I) or extending into both gametangia (H) and enveloped by the sporangial wall, of which, G and I show the sporangium adjoined by two cells and H shows the sporangium adjoined by four cells. A—H, scalariform conjugation; I, lateral conjugation.

by two cells" (Fig. 3, G), or protruding into the gametangia and with four walls which separate the two gametangia into four cells, when they are said to be "adjoined by four cells" (Fig. 3, H). There is also a type with zygosporc protruding into one gametangium but not into the other, this is said to be "adjoined by three cells". After conjugation, the gametangia usually remain straight, but in some species they become curved outwardly, *gametangia geniculate* (Fig. 3, H). (2) Reproduction by *aplanospores* which are formed directly from vegetative cells by contraction of the cell contents and the development of a secondary wall similar to that of the zygosporcs

(Pl. I, figs. 1, 2). (3) Reproduction by *parthenospores* which are formed by the gametes either in conjugation tubes or in gametangia, when conjugation is interrupted or is incomplete (Pl. II, figs. 2, 3). (4) Reproduction by *akinetes*. This is somewhat similar to the formation of aplanospores, but the walls are formed by the secondary thickening of the original walls of vegetative cells.

In some genera the entire cell content migrates and is entirely used up to form the zygospores, aplanospores, or parthenospores. In some others only a part of the cell content is used for spore formation, and the remaining cytoplasm stays in the gametangia and appears in the form of granules or irregularly shrunken membranes. Some genera are distinguished by having the gametangia filled with a lamellated, pectic-cellulose colloid after the cell contents have contracted to form the spore. These characters are used in some instances to separate genera.

The *sterile cells* on the fruiting filaments usually keep the form of the ordinary vegetative cells, but in some species they are inflated constantly in definite forms, *bullate*, *obovoid*, *ellipsoid*, *cylindrical*, or *inflated at both ends*. Their form and size are used for specific separation.

The fertile cells are commonly in long series, but in some species they are solitary, paired or shortly seriate interrupted by sterile cells. After the gametangia conjugate, the fertile cells mostly keep their arrangement in continuous series; in a few species they are separated from each other after conjugation.

Zygospores, aplanospores and parthenospores.—The form, size and the markings of the spore wall are very important for specific identification. The majority of the species usually have the spores constant in form, only a very few are *polymorphic*. In summary, the forms may be classified into four primary types, viz., *globose*, *obovoid*, *ellipsoid* and *quadrangular*, of which a number of variations are known (Fig. 4). The spore walls are composed of 3 or 4 layers, rarely 2 or 5. The outer wall, *epispor*e, is colorless and usually thin; the median wall, *mesospor*e, is often thick and yellow, yellowish brown,

brown or blue in color, rarely colorless, at maturity. The inner wall, *endospore*, generally is very thin and more or less indistinct. In some species the episporium or mesospore may be separated into two layers. The inner episporium and both outer and inner mesospore are either smooth or ornamented with various markings (*wrinkled, granulate, verrucose, reticulate,*

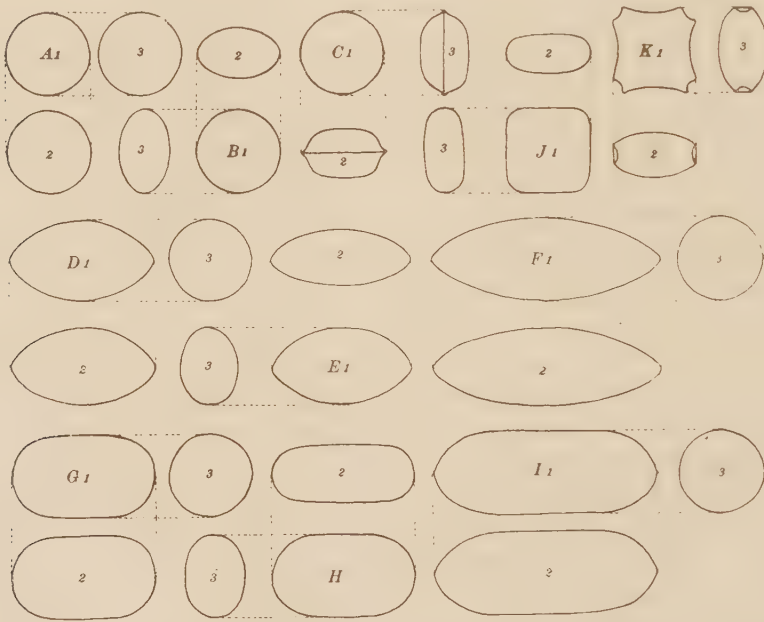


Fig. 4.—Shapes of Spores in Three Views. A, globose; B, depressed-globose or lenticular; C, depressed-globose and ridged; D, ellipsoid; E, depressed-ellipsoid; F, cylindric-ellipsoid; G, obovoid; H, depressed-obovoid; I, cylindric-obovoid; J, quadrangulate with rounded angles and straight sides; K, quadrangulate with retuse angles and concave sides. 1, face view; 2, lateral or edge view; 3, end view.

foveolate, denticulate, denticulately reticulate, punctate, pitted, scrobiculate, grooved, and ridged) as shown in figure 5. In some species the mesospore possesses a *suture* (Fig. 5, A) which is straight, irregularly wavy, but rarely regularly undulate in form. The ridge is also found on the episporium above the ridge of the mesospore. For specific identification, the type of mark-

ings of the spore wall must be determined very carefully, because the markings often have not well developed when the spores are in rather young stages, and usually also the spore content is deeply colored, which makes the markings less visible.

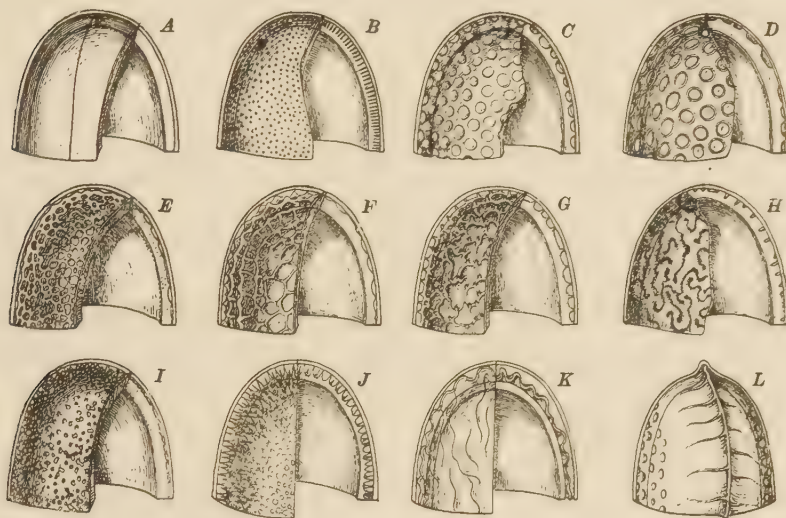


Fig. 5.—Various Markings of the Mesospores. A, smooth and with a suture; B, punctate; C, scrobiculate; D, pitted; E, reticulate; F, foveolate; G, denticulately reticulate; H, grooved; I, granulate to verrucose; J, denticulate; K, outer mesospore wrinkled and inner mesospore smooth; L, ridged and with lateral wall striate and polar surfaces scrobiculate. Left half of each spore, except L, showing the surface view and right half showing the section.

Two methods are helpful for these studies; (1) breaking the spores under the cover glass; (2) mounting the fruiting filaments in a drop of 30 per cent chromic acid to dissolve the cell contents.

Classification

The classification of the Zygnemataceae has certain difficulties, for the characteristics of some genera have been much confused. Therefore the classification of this family varies much according to the author's point of view. One of the

earliest workers, De Bary (1858), first sharply divided this family in two subfamilies, the Mesocarpeae and the Zygnemeae, and this separation was further supported by the careful studies of Wittrock (1872 and 1878) on spore formation of the Mesocarpeae. This classification is only based upon reproductive structures. From that time, this distinction has been retained by other workers. A most helpful suggestion was established by Palla (1894), and supported by Blackman and Tansley (1902) and others, notably G. S. West (1916), to the effect that the chromatophore characters rather than the modes of conjugation should be utilized as the primary basis in grouping members of the Zygnemataceae. Later on, these distinctions were modified by many other phycologists (Borge, 1913; Printz, 1927; West and Fritsch, 1927; Smith, 1933; Transeau, 1934). The classification was based in part on chromatophore structure and in part on the characteristics of the conjugating cells by which the division of this family into a number of genera becomes possible.

Of the recent workers, V. Czurda (1932), has condensed the number of genera into the earliest ones used, *Mougeotia*, *Zygnema* and *Spirogyra*. His classification is entirely based upon the characters of the chromatophores. G. M. Smith (1933) utilized the characteristics of both chromatophore and reproductive cells to divide this family as occurring in the United States in nine genera, *i. e.* *Mougeotia*, *Debarya*, *Mougeotiopsis*, *Zygnema*, *Hallasia*, *Zygogonium*, *Pleurodiscus*, *Spirogyra* and *Sirogonium*. More recently E. N. Transeau (1934) has classified this family in ten genera, which are also based on the nature of the chromatophore and the modes of reproduction, but he included the genus *Hallasia* as the aplanosporic species of *Zygnemopsis* and added to Smith's classification the genus *Temnogametum*. This classification has been used in this paper.

ZYGNEMATACEAE

Simple uniseriate unbranched filamentous algae; sometimes attached by rhizoidal branches or haptera, more often free; each cell containing one or more stellate, platelike, disc-shaped,

irregularly spherical or ribbon-like chromatophores; with or very rarely without pyrenoids, one or more than one in each chromatophore, in a single row or scattered; all cells except the original basal cell equally capable of vegetative multiplication; sexual reproduction by zygospores formed by the union of isogamous or heterogamous aplanogametes produced by the same or different filaments or both on paired conjugating filaments; asexual reproduction by aplanospores, akinetes or parthenospores; spore wall typically of three layers, epispore, mesospore and endospore, sometimes four, rarely two or five, layers; inner epispore and mesospore or mesospores smooth or variously marked, mesospore usually colored, rarely colorless; in germination the epispore and mesospore ruptures, the endospore then forms the membrane of the new plant, which at once divides into an indivisible basal cell and a continuously divisible filament cell; all species occur in fresh water.

Key to the Genera of Zygnemataceae

- 1—Chromatophores stellate, irregularly spherical
or disc-shaped, usually 2 in number2
- 1—Chromatophores plate-like or ribbon-like, 1—
16 in number5
- 2—Zygospores enclosed by the sporangial walls;
chromatophores irregularly spherical or disc-
shaped3
- 2—Sporangial wall absent; chromatophores stel-
late4
- 3—Chromatophores irregularly sphericalII. Zyogonium
- 3—Chromatophores disc-shapedPleurodiscus*
- 4—Gametangia filled by a pectic-cellulose colloid.III. Zygnemopsis
- 4—Gametangia not filled by a pectic-cellulose
colloidI. Zygnema
- 5—Chromatophores axile, plate-like and straight.6
- 5—Chromatophores parietal, ribbon-like, more
or less spiral9
- 6—Pyrenoids absentMougeotiopsis*
- 6—Pyrenoids present7
- 7—Gametangia cut off from the ends of the
vegetative cells before conjugationTemnogametum*

- 7-Gametangia formed from the usual vegetative cells8
 8-Gametangia filled by pectic-cellulose colloid ..Debarya*
 8-Gametangia not filled by pectic-cellulose colloidIV. Mougeotia
 9-Conjugation tubes well developedV. Spirogyra
 9-Conjugation tubes absentVI. Sirogonium

*Indicating these genera are not found in the writer's collections.

I. *Zygnema* Agardh 1824

Vegetative cells usually as long as broad or somewhat longer; end wall plane and even; two or sometimes 3 or 4 axial stellate chromatophores in each cell, each containing a central pyrenoid; nucleus suspended between these two chromatophores; sexual reproduction by zygospores formed in the conjugation tubes or gametangia, conjugation scalariform, rarely lateral; asexual reproduction by parthenospores or aplanospores; spore wall usually 3- rarely 4-layered, mesospore yellow to brown or blue at maturity, smooth or with various markings.

The plants of this genus are very common, being found in rice farms and muddy ditches or pools; more often distributed in rather shallow and quiet waters. They mostly form dull yellow-green masses floating in the water during the fruiting stages, pure or scattered among some other filamentous algae.

There are eleven species found in the writer's collections.

Key to the species of *Zygnema*

- 1-Reproduction by aplanospores1. *Z. spontaneum*
 1-Reproduction by zygospores2
 2-Zygospores in the conjugation tubes3
 2-Zygospores in the gametangia4
 3-Spore wall of 4 layers, inner mesospore granulate to verrucose2. *Z. verrucosum*
 3-Spore wall of 3 layers, mesospore coarsely scrobiculate3. *Z. sinense*
 4-Spore wall smooth4. *Z. insigne*
 4-Spore wall not smooth5

- 5-Zygospores blue at maturity, mesospore coarsely scrobiculate8. *Z. carinthiacum*
- 5-Zygospores yellow to yellowish brown at maturity6
- 6-Vegetative cells between $18-22\mu$ in diameter7
- 6-Vegetative cells between $23-36\mu$ in diameter8
- 7-Mesospore with pits $4.5-6.5\mu$ in diameter..6. *Z. extenu*
- 7-Mesospore with pits $2-3\mu$ in diameter7. *Z. tenue*
- 8-Vegetative cells between $23-29\mu$ in diameter9
- 8-Vegetative cells between $27-36\mu$ in diameter10
- 9-Vegetative cells $23-26\mu$ in diameter; fertile cells greatly enlarged on both side by the zygospores5. *Z. calosporum*
- 9-Vegetative cells $25-29\mu$ in diameter; fertile cells cylindrical or enlarged on the conjugating side9. *Z. subcruciatum*
- 10-Fertile cells mostly cylindrical; mesospore deeply scrobiculate, pits $4.5-7.5\mu$ in diameter10. *Z. fanicum*
- 10-Fertile cells mostly more inflated on the conjugating side; mesospore pitted, pits about 4μ in diameter11. *Z. stellinum*

1. *Zygnema spontaneum* Nordstedt 1878¹

(Pl. I, figs. 1, 2)

Vegetative cells $19-22\mu$ diameter, $19-32\mu$ long; reproduction by aplanospores; fertile cells mostly cylindrical, sometimes slightly enlarged by the aplanospores; aplanospores subglobose or globose, $19-22\mu$ diameter, $22-23\mu$ long; mesospore finely scrobiculate, yellow to yellowish brown at maturity.

1. The descriptions included in this paper are based upon the Chinese material, and not upon the types when these are of European or other foreign origin. Significant variations from the type are discussed where they occur.

In one of the writer's collections this species is represented very abundantly and nearly pure; reproduction is only by the aplanospores; no trace of zygospore formation occurred. In 1909, G. S. West described this species from Australian specimens and mentioned these plants as reproduction by both zygospores and aplanospores. According to Nordstedt's description, it is doubtful if this species has zygospores. In size and habits these Chinese plants are very close to *Zygnema spontaneum* Nordstedt.

In a rice farm, Hsiao-Lung-Kan, Nov. 11, 1934 (S642).

2. *Zygnema verrucosum*, sp. nov.

(Pl. I, figs. 3, 4)

Cellulis vegetativis $24-26\mu$ latis, $29-48\mu$ longis; conjugatione scalari; zygosporis in tubo conjugationis, subglobosis vel depresso-globosis, $38-55\mu$ latis, $32-37\mu$ longis; membrana quadruplici; episporio hyalino et tenui, mesosporio exteriori tenui, flavescenti et irregulariter rugoso, mesosporio interiori crasso, fuscescenti et dense granulato vel verrucoso, endosporio tenui.

Vegetative cells $24-26\mu$ diameter, $29-48\mu$ long; conjugation scalariform; zygospores in the conjugation tubes, subglobose to depressed-globose, $38-55\mu$ diameter, $32-37\mu$ long; spore wall of four layers, episporium colorless and thin, outer mesospore thin, yellow and irregularly wrinkled, inner mesospore thick, yellowish brown and densely granulate to verrucose, endospore thin.

The species is very sharply characterized by its 4-layered spore wall, of which the outer mesospore is yellow and wrinkled and the inner mesospore yellowish brown and granulate to verrucose which distinguish it from *Zygnema Pawhuskæ* Taft. However, *Z. Pawhuskæ* has the outer mesospore smooth with a distinct equatorial suture, the "outer sporangium wall" (?) thickened up to $3-6\mu$, and the vegetative cells only $21-24\mu$ in diameter.

In a rice farm, Li-Tze-Pa, Jan., 1934. Type in C. C. Jao collections No. S675.

3. *Zygnema sinense*, sp. nov.

(Pl. I, fig. 5)

Cellulis vegetativis $25-27\mu$ latis, $25-48\mu$ longis; conjugatione scalari; zygosporis in tubo conjugationis, subglobose vel depresso-globose, non compressis, $40-48\mu$ latis, $35-42\mu$ longis; membrana triplici, mesosporio crasse scrobiculato, scrobiculis $5-8\mu$ diametro, intervallis $3.2-9\mu$ latis, maturitate bruneo.

Vegetative cells $25-27\mu$ diameter, $25-48\mu$ long, conjugation scalariform; zygospor in the conjugation tubes, subglobose to depressed-globose, not compressed; spore wall of three layers; mesospore coarsely scrobiculate, pits $5-8\mu$ diameter, $3.2-9\mu$ apart, brown at maturity.

This new species bears some similarity to *Zygnema Lawtonianum* Taft and *Z. areolatum* Transeau. It differs from the first in having the epispore distinctly separated from the wall of the conjugation tubes, rather larger zygospor without equatorial suture, and the scrobiculations much larger in diameter; from the second, in having smaller vegetative cells, the mesospore not divided into two layers, and the scrobiculations larger.

In a rice farm, Li-Tze-Pa, Jan., 1934. Type in C. C. Jao collections and Herb. Univ. Mich., No. S669.

4. *Zygnema insigne* (Hassall) Kützing 1849

(Pl. I, fig. 6)

Vegetative cells $25-30\mu$ diameter, $26-86\mu$ long, conjugation scalariform or lateral; fertile cells cylindrical or slightly enlarged by the zygospor; zygospor globose to subglobose or sub-obovoid, $27-32\mu$ diameter, $32-38\mu$ long, mesospore smooth, yellow at maturity.

The typical plants have the conjugation mostly lateral and but occasionally scalariform. These local plants were found in scalariform conjugation, but are otherwise quite close to the typical form.

In a rice farm near Chungking, Feb., 1932 (S316).

5. *Zygnema calosporum*, sp. nov.

(Pl. I, fig. 7)

Cellulis vegetativis $23\text{--}26\mu$ latis, $16\text{--}48\mu$ longis; conjugatione scalari; cellulis fructiferis abbreviatis et zygospora valde inflatis; zygosporis globosis vel subglobosis, $29\text{--}35\mu$ latis, $32\text{--}35\mu$ longis; mesosporio dense scrobiculato, scrobiculis $1.5\text{--}2.5\mu$ diametro, intervallis $1\text{--}1.5\mu$ latis, maturitate fuscescente.

Vegetative cells $23\text{--}26\mu$ diameter, $16\text{--}48\mu$ long; conjugation scalariform; fertile cells shortened and greatly enlarged by the zygosporidia; zygosporidia globose to subglobose, $29\text{--}35\mu$ diameter, $32\text{--}35\mu$ long; mesospore densely scrobiculate, pits $1.5\text{--}2.5\mu$ in diameter, $1.0\text{--}1.5\mu$ apart, yellowish brown at maturity.

This species is close to *Zygnema substellinum* Taft, but the rather greater diameter and lesser length of the vegetative cells and the much smaller zygosporidia with finely and densely scrobiculate mesospore distinguish it.

In a rice farm, Tseng-Chia-Yen, Dec. 12, 1933. Type in C. C. Jao collections and Herb. Univ. Mich., No. S745.

6. *Zygnema extenua*, sp. nov.

(Pl. I, fig. 8)

Cellulis vegetativis $19\text{--}22\mu$ latis, $32\text{--}48\mu$ longis; conjugatione scalari vel interdum laterali; cellulis fructiferis plus minusve zygospora inflatis; zygosporis subglobosis vel subobovoidis, $23\text{--}32\mu$ latis, $29\text{--}35\mu$ longis; mesosporio scrobiculato, scrobiculis $4.5\text{--}6.5\mu$ diametro, intervallis $2\text{--}3\mu$ latis, maturitate fuscescente.

Vegetative cells $19\text{--}22\mu$ diameter, $32\text{--}48\mu$ long; conjugation scalariform or sometimes lateral; fertile cells more or less enlarged by the zygosporidia; zygosporidia subglobose to subobovoid, $23\text{--}32\mu$ diameter, $29\text{--}35\mu$ long; mesospore scrobiculate, pits $4.5\text{--}6.5\mu$ diameter and $2\text{--}3\mu$ apart, yellowish brown at maturity.

In size this species is quite close to *Zygnema tenue* Kützing, but the scrobiculations of the mesospore of this new species are much larger and sharper. These larger scrobiculations are like those of *Zygnema fanicum* Li, but this new species is much smaller in the dimensions of all cells. Comparing this species with *Z. subtile* Kützing, we find *Z. subtile* is smaller, especially in its zygospores, and has smaller pits.

In a rice farm near Shih-Chiao-Ch'ang, June, 1933. Filaments scattered among many other filamentous algae. Type in C. C. Jao collections No. S497.

7. *Zygnema tenue* Kützing 1849

(Pl. I, figs. 9, 10)

Vegetative cells 18—22 μ diameter, 32—48 μ long; conjugation scalariform; fertile cells usually more enlarged by the zygospores on the conjugating side than the outer; zygospores in the gametangia, obovoid or subglobose, 23—29 μ diameter, 28—38 μ long, mesospore scrobiculate, pits 2—3 μ diameter, 3—4 μ apart, yellowish brown at maturity.

In a rice farm near Liu-Tien-Tze, Feb., 1932 (S329).

8. *Zygnema carinthiacum* Beck 1929

(Pl. I, figs. 11, 12)

Vegetative cells 22—30 μ diameter, 22—82 μ long; conjugation scalariform; fertile cells cylindrical or slightly enlarged on the conjugating side by the zygospores; zygospores in the gametangia, globose, subglobose or subobovoid, 25—38 μ diameter, 32—45 μ long, mesospore thick, more or less distinctly lamellose and coarsely scrobiculate, pits 3.2—6.4 μ in diameter and about 3.2 μ apart, distinctly marked with a concentric circle surrounding each scrobiculation, blue at maturity.

In rice farms near Lung-Yin-Ch'ang, Dec., 1933 (S103 and S150); in rice farms near Fou-Tu-Kuan, Nov., 1930 (S312 and S340); in a rice farm, Ta-Chi-Kou, Dec. 15, 1933 (S735); in a muddy pool, Tseng-Chia-Yen, Dec. 14, 1933 (S726).

9. *Zygnema subcruciatum* Transeau 1934

(Pl. I, fig. 13)

Vegetative cells $25-29\mu$ diameter, $19-101\mu$, mostly $22-48\mu$ long; conjugation scalariform; fertile cells mostly cylindrical, sometimes slightly enlarged on the conjugating side by the zygospores; zygospores subglobose to obovoid, $25-32(-35)\mu$ diameter, $29-45\mu$ long, mesospore finely scrobiculate, pits $1.5-2.0\mu$ diameter, $3-4\mu$ apart, yellowish brown at maturity.

This local form has the zygospores rather longer than in Transeau's type.

In rice farms near Fou-Tu-Kuan and Niu-Kioh-To, Jan., 1934 (S628 and S700).

10. *Zygnema fanicum* Li 1934

(Pl. I, figs. 14, 15)

Vegetative cells $27-32\mu$ diameter, $38-83\mu$ long; conjugation scalariform; fertile cells a little enlarged by the zygospores, usually on the conjugating side; zygospores in the gametangia, globose to obovoid, slightly compressed, $32-38\mu$ diameter, $32-48\mu$ long, $22-29\mu$ thick, spore wall of three layers, mesospore thick, lamellose and deeply scrobiculate, undulate in section, pits $4.5-7.0\mu$ diameter, $2-3\mu$ apart, yellow at maturity.

This species is most remarkable in that it has the mesospore thick, lamellose and deeply scrobiculate. These local plants have the dimensions a little larger than the typical form.

In a rice farm near Shih-Chiao-Ch'ang, Jan., 1933 (S424).

11. *Zygnema stellinum* (Vaucher) Agardh 1824

(Pl. I, fig. 16, 17)

Vegetative cells $27-38\mu$ diameter, $19-83\mu$ long; conjugation scalariform; fertile cells mostly enlarged on the conjugating side by the zygospores; zygospores obovoid or subglobose, $29-39\mu$ diameter, $29-43\mu$ long, mesospore pitted, pits about 4μ in diameter and 4μ apart, yellowish brown to brown at maturity.

In rice farms near the vicinities of Chungking and Chiangpei, Dec. and Nov. 1933 (S110, S158, S316, S734 and S740). These plants were very commonly found in the writer's collections.

II. *Zygogonium* Kützing 1843

Filaments usually simple, with rhizoids or haptera, very occasionally branched; vegetative cells 0.5—9.5 diameters long, end walls plane; two or one axile chromatophores in each cell, in form irregularly spherical, without or with short radial processes, containing a central pyrenoid in each one; cell sap colorless or purple to violet; reproduction mostly by akinetes and aplanospores, rarely by zygospores formed by scalariform or lateral conjugation; zygospores inclosed in a sporangial wall which dehisces by an equatorial suture; spore wall of three layers, mesospore smooth or variously marked, yellow to yellowish brown at maturity.

These plants occur in shallow water or on moist soils.

One species was found in the writer's collections.

1. *Zygogonium sinense*, sp. nov.

(Pl. II, figs. 18-25)

Cellulis vegetativis 16—17 μ latis, 38—64 μ longis, membrana tenui; chromatophoris 2, irregulariter globosis; generationibus zygosporis, interdum parthenosporis; sporis in sporangiorum membranis; conjugatione scalari vel laterali; zygosporis aspectu polari globosis vel subglobosis et aspectu equatoriali depresso-globosis, 29—36 μ latis, 32—35 μ longis, 22—25 μ crassis; parthenosporis ex gametis econjugialibus emissis in tubo conjugationis, globosis vel subglobosis, non compressis, 22—25 μ diametro; membrana zygosporae vel parthenosporae triplici; mesosporio zygosporae aspectu equatoriali insigniter costato, faciebus polaribus perspicue scrobiculatis, membranis laterilibus inter costam et facies polares plerumque irregulariter striatis vel imperfectum scrobiculatis; mesosporio parthenosporae non costato, solum palam scrobiculato; membrana sporae maturitate flavescence vel fuscescente.

Vegetative cells $16-17\mu$ diameter, $38-64\mu$ long, cell wall thin; two chromatophores, irregularly spherical in form; reproduction by zygospores, sometimes by parthenospores, enclosed in sporangial wall; conjugation scalariform or lateral; zygospores globose or subglobose in polar view and depressed-globose in equatorial view, $29-38\mu$ diameter, $32-35\mu$ long, $22-25\mu$ thick; parthenospores formed by the non-conjugating gametes in the conjugation tubes, globose to subglobose, not compressed, $22-25\mu$ diameter; spore wall of both zygospores and parthenospores being three layers; mesospore of zygospore with a well developed ridge showing conspicuously in the equatorial view, both polar faces sharply scrobiculate, the lateral walls between the polar faces and ridge usually irregularly striate or incompletely scrobiculate; mesospore of parthenospores without ridge, only sharply scrobiculate; spore wall yellow to yellowish brown at maturity.

This species is near *Zygogonium exuvielliforme* Jao in Taylor MSS and *Z. Heydrichii* (Schmidle) Transeau, the only species which are characterized by the reproduction of zygospores with a scrobiculate mesospore. *Zygogonium exuvielliforme*, a Colombian plant, has larger dimensions of all cells, especially zygospores ($38-51\mu$ diameter and $35-42\mu$ thick), undulated ridge and smooth lateral wall to distinguish from *Zygogonium sinense*. *Zygogonium Heydrichii* was only found by Schmidle from Australia and described in 1897. In his original description, he mentioned the vegetative cells as $14-20$ (mostly 20) μ in diameter, $25-66\mu$ long, conjugation lateral, and zygospores $24-28\mu$ in diameter and 32μ long. This new species differs from it in having larger zygospores and the mesospore ridged and with the scrobiculations only on the polar faces.

This species was first found in the writer's collections at Nanking, containing numerous well fruiting filaments. It also found in his specimens at Chungking, collected from a rice farm near Shih-Chiao-Ch'ang, Feb., 1932. The second sample has only a few filaments scattered among other filamentous algae, but they have characteristics quite similar to the Nanking

specimens. Type in C. C. Jao collections and Herb. Univ. Mich., No. N243.

III. *Zygnemopsis* (Skuja) Transeau 1934

Vegetative cells 2—5 (—10) diameters long, end walls plane; two (sometimes 3—6) stellate chromatophores, each containing a central pyrenoid; reproduction by parthenospores, aplanospores or zygozooetes, at time of conjugation the vegetative cells lengthen to form the gametangia; fertile cells filled by a dense lamellate pectic-cellulose colloid; spore wall of three layers, mesospore smooth or with various markings, yellow to brown at maturity.

Only one species was found in the writer's collections.

1. *Zygnemopsis quadrata*, sp. nov.

(Pl. II, figs. 26—30)

Cellulis vegetativis 13—16 μ latis, 29—71 μ longis; chromatophoris 2, interdum 3 vel 4, stellatis; conjugatione scalariformi; cellulis fructiferis plus minusve geniculatis; zygozooetis in tubo conjugationis, plerumque in gametangia extensis; tubo conjugationis latissimo; zygozooetis aspectu faciei plerumque quadrangularibus, angule maturitate rotundatis, vel interdum subglobosis vel quadrangulatis obovoideis, 38—48 μ latis et 45—60 μ longis, aspectu marginali obovoideis, 29—32 μ crassis; membrana sporae triplici; episporio tenui et hyalino, plerumque a mesosporio valde disjuncto et fere in cornibus anterioribus posterioribusque cornulis quattuor; mesosporio scrobiculato, scrobiculis circum 3 μ diametro, intervallis 1.5—2.5 μ latis, vel interdum in partibus reticulato, margine laterali-mediano culmine et sulco circumdato, maturitate aureo; inter episporio et mesosporio materia flavescenti impleta, plus minusve distincte lamellosa.

Vegetative cells 13—16 μ diameter, 29—71 μ long; 2 stellate chromatophores, sometimes 3 or 4; conjugation scalariform; fertile cells more or less geniculate; zygozooetes in the conjugation tubes, mostly extending into the gametangia; conjugation

tion tubes very wide; zygospores mostly quadrangular in face view, with rounded angles at maturity, or sometimes subglobose to quadrangular obovoid, $38-48\mu$ diameter and $45-60\mu$ long, obovoid in edge view, $29-32\mu$ thick; spore wall of three layers; epispore smooth and colorless, usually widely separated from the mesospore and usually forming four hornlike processes of varying length from the anterior and posterior corners, mesospore scrobiculate, pits about 3μ in diameter, $1.5-2.5\mu$ apart, sometimes reticulate on some portion, with a circular ridge and suture surrounding the lateral median margin to divide the spore into upper and lower halves, golden yellow at maturity; between the epispore and mesospore filled with yellow material (pectic-cellulose colloid?), more or less distinctly lamellose.

This species is nearest to *Zygnemopsis Stephensiae* Transeau and *Z. sinensis* Transeau, but differs from the first in having larger zygospores with rounded angles, from the second in having greater dimensions of all cells, and from both in having the yellow, lamellose material filling up the space between the mesospore and epispore generally to separate the epispore widely from the mesospore.

In a rice farm near Hsian-Kuo-Shih, Dec., 1933 (S557); in a stony pool near Liu-Chia-Tan, Dec. 27, 1933 (S588); in rice farms, Li-Tze-Pa, 1934 (S623, S669 and S681). Type in C. C. Jao collections and Herb. Univ. Mich., No. S669.

IV. *Mougeotia* Agardh 1824

Filaments simple, rarely with one or two celled branches, rhizoids or haptera common; cells $5-20$ diameters long, end walls plane; one or two axile plate-like chromatophores, containing pyrenoids in a single row or scattered; reproduction by zygospores or aplanospores; conjugation scalariform, rarely lateral; mesospore smooth or with various markings, yellow to brown or hyaline at maturity.

The members of this genus are commonly found in rice farms, pools, ditches, ponds and streams. They are pure or scattered among some other algae.

Ten species found in the writer's collections.

Key to the Species of Mougeotia

- 1-Sporangial wall absent, zygospores free in the conjugation tubes and enveloped by a yellow and wrinkled integument which forms 4 processes extending in the gametangia ...4. *M. sphaerocarpa*
- 1-Zygospores enveloped in the sporangial wall..2
- 2-Sporangium adjoined by 2 cells3
- 2-Sporangium adjoined by 4 cells7
- 3-Spore wall smooth4
- 3-Spore wall not smooth5
- 4-Vegetative cells 6—13 μ diameter; zygospores 16—25 μ diameter1. *M. parvula*
- 4-Vegetative cells 20—27 μ diameter; zygospores 27—35 μ diameter2. *M. scalaris*
- 5-Zygospores transversely ellipsoid; episporangium thick and lamellose, mesospore verrucose ...5. *M. lamellosa*
- 5-Zygospores globose rarely subglobose; episporangium thin, not lamellose; mesospore punctate or reticulate6
- 6-Vegetative cells 16-22 μ diameter; mesospore punctate, with a equatorial, undulate ridge and suture3. *M. ornata*
- 6-Vegetative cells 19—32 μ diameter; mesospore reticulate, without ridge and suture6. *M. globulisporea*
- 7-Spore wall smooth8
- 7-Spore wall pitted9
- 8-Zygospores 19—26 μ on each side, angles retuse7. *M. viridis*
- 8-Zygospores 25—36 μ on each side, angles rounded8. *M. virescens*
- 9-Vegetative cells 8—10 μ diameter; zygospores with rounded angles9. *M. rotundangulata*
- 9-Vegetative cells 7—13 μ diameter; zygospores with truncate or retuse angles10. *M. quadrangulata*

1. *Mougeotia parvula* Hassall 1843

(Pl. II. figs. 31, 32)

Two types probably referable to this species were found in the writer's collections:

I. Vegetative cells $8-13\mu$ diameter, $48-115\mu$ long; chromatophores containing 4—6 (—9) pyrenoids in a single row; gametangia straight or slightly geniculate; zygospores formed wholly in the conjugation tubes, globose, $16-25\mu$ in diameter, wall smooth, yellowish brown at maturity.

II. All the characteristics are the same as in type I, excepting the measurements being smaller, vegetative cells $6-8\mu$ diameter, $41-77\mu$ long; chromatophores with 2—4 pyrenoids in a single row; zygospores $16-19\mu$ in diameter.

Both collected in rice farms near Lung-Yin-Ch'ang, Dec., 1933. They were found in separate collections (type I in S149 and S154 and type II in S132), constantly showing the difference in size.

2. *Mougeotia scalaris* Hassall 1842?

(Pl. III, fig. 33)

Vegetative cells $20-27\mu$ diameter, $38-124\mu$ long; chromatophores with 2—8 pyrenoid, usually 4, in a single row; gametangia straight or slightly geniculate; sporangia adjoined by four cells; zygospores globose, rarely subglobose, $27-35\mu$ diameter, mesospore smooth, with a prominent suture, yellowish brown at maturity.

The number and arrangement of the pyrenoids of this species were not mentioned in the former descriptions. In 1926, Transeau gives only a drawing showing the pyrenoids of these plants as numerous and scattered in the chromatophores. It is hard to conclude which is correct character—whether the pyrenoids are typically numerous or only a few, in a single row or scattered. The Chinese plants have the pyrenoids 2—8, usually 4, and in a single row; otherwise, excepting a little smaller size and a prominent suture, they are similar to *Mougeotia scalaris* Hassall.

In rice farms near Lung-Yin-Ch'ang, Dec., 1933 (S141, S145, S150, S152 and S154); in a rice farm, Hsiao-Lung-Kan, Nov. 4, 1934 (S692).

3. *Mougeotia ornata*, sp. nov.

(Pl. III, figs. 34, 35)

Cellulis vegetativis 16—22 μ latis, 76—176 μ longis; pyrenoidis 4—10, plerumque 6, monostichis; gametangiis erectis; zygosporis in tubo conjugationis, globosis, raro subglobosis, 28—35 μ latis; episporio tenui; mesosporio crasso, plus minusve regulariter et distincte punctato, culminis et sulco conspicuo spicibus aequidistante, culminis margine tenuiter undulato, maturitate fusciscenti.

Vegetative cells 16—22 μ diameter, 76—176 μ long; chromatophores containing 4—10, usually 6 pyrenoids in a single row, gametangia straight; zygosporangia in the conjugation tubes, globose, rarely subglobose, 28—35 μ diameter; episporium thin; mesospore thick, more or less regularly and distinctly punctate, with a prominent ridge and suture, margin of the ridge finely undulate, yellowish brown at maturity.

This species bears some of the characteristics of *Mougeotia operculata* Transeau and *M. microspora* Taft. It is distinguished, however, from the first by having larger globose zygosporangia which are punctate and with a finely undulate ridge, from the second by having the globose zygosporangia without the pectic and thickened episporium and the mesospore with an undulately equatorial ridge and suture.

In a stony pool near Hsian-Kuo-Shih, Dec., 1934 (S578 and S582). Type in C. C. Jao collections and Herb. Univ. Mich., No. S587.

4. *Mougeotia lamellosa* Jao 1935

(Pl. III, figs. 36, 39)

Vegetative cells 19—30 μ diameter, 60—185 μ long; chromatophores containing 4—9 pyrenoids in a single row; gametangia straight; zygosporangia adjoined by two cells, situated in the conjugation tubes, transversely ellipsoid, 28—45 μ diameter, 24—32 μ long, episporium smooth, lamellose, and thick, especially at the ends, mesospore verrucose, yellow at maturity.

This species is characterized by the thick and lamellose epispore, verrucose mesospore, and smaller size of zygospores, features which distinguish it from the related species *M. pulchella* Wittrock.

In rice farms near Chungking, Jan. and Dec., 1933 (S132 and S404).

5. *Mougeotia globulispora* Jao 1935

(Pl. III, figs. 38, 39)

Vegetative cells 19—32 μ diameter, 96—288 μ long; pyrenoids 6—12, in a single row; fertile cells straight; sporangium adjoined by two cells, wholly situated in the conjugation tube, globose or subglobose, 32—39 μ diameter, 32—35 μ (—38) μ long; mesospore irregularly and finely scrobiculate to reticulate, yellow to brown at maturity.

The larger size of vegetative cells and the smaller dimensions of zygospores distinguish this species from *Mougeotia megaspora* Wittrock.

In rice farms near Chungking, Feb., 1932 and Jan., 1933 (S316, S427, S405 and S451).

6. *Mougeotia sphaerocarpa* Wolle 1887

(Pl. III, figs. 40, 41)

Vegetative cells 19—22 μ diameter, 64—192 μ long; pyrenoids 4—7 in each cell, a single row; gametangia slightly geniculate; sporangial wall absent; zygospores free in the greatly enlarged conjugation tubes, usually extending into the gametangia, obovoid or subglobose, 41—55 μ diameter, 41—43 μ long; spore wall of three layers, smooth and yellow to brown at maturity; zygospores enveloped by irregularly wrinkled, thin and yellow integuments which form four processes extending into the gametangia.

The integuments constantly occurred about the zygospores in the writer's specimens.

In a rice farm near Chungking, Aug., 1930 (S270: S4).

7. *Mougeotia viridis* (Kützing) Wittrock 1872

(Pl. III, figs. 42, 43)

Vegetative cells $6-9\mu$ diameter, $73-160\mu$ long; chromatophore with 2—6 pyrenoids in a single row; gametangia more or less geniculate; sporangium adjoined by 4 cells; zygospores quadrangulate, with concave sides and retuse angles, $19-26\mu$ on each side, obovoid in lateral view, $15-18\mu$ thick; spore wall smooth and colorless.

This local form has longer vegetative cells and a little smaller zygospores, otherwise being like typical forms.

In rice farm near Lung-Yin-Ch'ang, Dec., 1933 (S152); in rice farms near Fou-Tu-Kuan, Nov., 1933 (S329 and S320).

8. *Mougeotia virescens* (Hassall) Borge 1923

(Pl. III, fig. 44)

Vegetative cells $8-9\mu$ diameter, $109-224\mu$ long; gametangia geniculate; sporangium adjoining 4 cells; zygospores quadrangulate, with concave sides and rounded angles, $25-36\mu$ long and wide, spore wall smooth and colorless.

In a rice farm near Lung-Yin-Ch'ang, Dec., 1933 (S144).

9. *Mougeotia rotundangulata*, sp. nov.

(Pl. III, figs. 45, 46)

Cellulis vegetativis $8-10\mu$ latis, (161—) $200-420\mu$ longis; pyrenoids 8—14, monostichis; zygosporangiis inter 4 cellulas sitis; zygosporis tumidis quadrangularibus, $32-35\mu$ latis, $32-35\mu$ longis, a latere visis ellipsoideis, angulis rotundatis; mesosporio foveolis rotundatis ornato, maturitate hyalino.

Vegetative cells $8-10\mu$ diameter, (161—) $200-420\mu$ long; chromatophore containing 8—14 pyrenoids in a single row; zygosporangium adjoined by four cells; zygospores quadrangular, somewhat tumid, $32-35\mu$ diameter $32-35\mu$ long, ellipsoid in lateral view, angles rounded; mesospore ornamented with rounded pits, colorless at maturity.

This species is related to *Mougeotia austriaca* Czurda, *M. quadrangulata* Hassall and *M. punctata* Wittrock, but differs from the first chiefly in having the pyrenoids 8—16 in each cell and the spore wall colorless, from the second in having rather smaller dimensions of all cells excepting the length of the vegetative cells, and the zygospores with convex or sometimes straight sides in front view and rounded angles, and from the third chiefly in having the zygospores with rounded angles and the vegetative cells smaller in diameter and greater in length.

In a rice farm near Lung-Yin-Ch'ang, Dec., 1933. Type in C. C. Jao collections No. S105.

10. *Mougeotia quadrangulata* Hassall 1843

(Pl. III, fig. 47)

Vegetative cells 7—13 μ diameter, 56—280 μ long; chromatophore containing 6—16 pyrenoids in a single row; conjugating cells geniculate; zygosporangium adjoining 4 cells; zygospores quadrangular, 29—38 μ on each side, with truncate or slightly incurved angles and concave side in front view, ellipsoid in lateral view; mesospore colorless and pitted.

In a rice farm near Lung-Yin-Ch'ang, Dec., 1933 (S149).

V. *Spirogyra* Link 1820

Filaments simple or sometimes with rhizoids or haptera; vegetative cells 0.5—30 diameters long, end walls plane, colligate, semireplicate, or replicate; chromatophores 1—16, parietal and ribbon-like, nearly straight or usually spiral, containing a single row of pyrenoids; nucleus central; sexual reproduction by zygospores, conjugation scalariform or lateral, conjugation tubes well developed, formed from both male and female gametangia or from the male cell only; asexual reproduction by aplanospores, parthenospores or akinetes; spore wall typically of three layers, 2-4- or 5-layered in some species, inner episporic and mesospore or mesospores smooth or with various markings, yellow to brown at maturity.

The plants of this genus are very commonly found in Szechwan, being distributed in rice farms, ditches, pools, and streams. They are very often form light green, yellow-green, dull green or deep green masses in the water, pure or scattered among many other filamentous algae. During the fruiting stages, they usually form yellow-green, dull green or yellowish brown, dense masses floating on the water surface.

There are fifty-one species in the writer's collections.

Key to the Species of Spirogyra

- 1-End walls plane2
- 1-End walls replicate29
- 2-Spore wall smooth3
- 2-Spore wall not smooth20
- 3-Chromatophore one (rarely two in some cells)4
- 3-Chromatophores more than one (rarely one in some cells)16
- 4-Conjugation tubes formed by the male gametangia only5
- 4-Conjugation tubes formed by both male and female gametangia7
- 5-Fertile cells inflated on conjugating side, separating from each other as the spores near maturity2. *S. gibberosa*
- 5-Fertile cells inflated on both sides, not separating from each other as the spores near maturity6
- 6-Vegetative cells 13—16 μ diameter1. *S. Liana*
- 6-Vegetative cells 19—22 μ diameter3. *S. Chenii*
- 7-Vegetative cells between 16—22 μ in diameter8
- 7-Vegetative cells between 22—36 μ in diameter10
- 8-Vegetative cells 16—19 μ diameter; fertile cells clearly inflated4. *S. fennica*
- 8-Vegetative cells 19—22 μ diameter; fertile cells cylindrical or very slightly enlarged by the zygospores9

- 9-Sterile cells greatly bullate; zygo-
spores 22—29 μ diameter6. *S. bullata*
- 9-Sterile cells cylindrical; zygo-
spores 18—22 μ diameter5. *S. communis*
- 10-Fertile cells cylindrical or enlarged by
the zygo-
spores11
- 10-Fertile cells inflated14
- 11-Zygo-
spores obovoid, with broad ends12. *S. longata*
- 11-Zygo-
spores ellipsoid12
- 12-Zygo-
spores 22—29 μ diameter; vegetative
cells curved to spiral9. *S. intorta*
- 12-Zygo-
spores between 28—36 μ diameter;
vegetative cells straight13
- 13-Vegetative cells 25—30 μ diameter; zygo-
spores 28—31 μ diameter10. *S. Juergensii*
- 13-Vegetative cells 29—36 μ diameter; zygo-
spores 28—40 μ diameter13. *S. singularis*
- 14-Fertile cells inflated on the conjugating
side; zygo-
spores ellipsoid15
- 14-Fertile cells inflated on the outer side;
zygo-
spores ellipsoid11. *S. Borgeana*
- 14-Fertile cells inflated on both sides; zygo-
spores polymorphic—globose, subglobose, ob-
ovoid and ellipsoid zygo-
spores occurring on
same filament7. *S. polymorpha*
- 15-Vegetative cells 24—29 μ diameter; sterile
cells cylindrical; fertile cells separating
from each other after conjugation8
- 15-Vegetative cells (26—) 29—36 μ diameter;
sterile cells inflated; fertile cells not separat-
ing from each other after conjugation14. *S. varians*
- 16-Vegetative cells between 35—48 μ in dia-
meter17
- 16-Vegetative cells more than 73 μ in dia-
meter18
- 17-Vegetative cells 35—38 μ diameter; zygo-
spores ellipsoid, 29—32 μ in diameter15. *S. microspora*
- 17-Vegetative cells 35—42 μ diameter; zygo-
spores obovoid, 35—37 μ in diameter16. *S. decimina*
- 17-Vegetative cells 38—48 μ diameter; zygo-
spores ellipsoid, 38—51 μ in diameter17. *S. biformis*

- 18-Vegetative cells 115—128 μ diameter; 6 chromatophores, sometimes 4 or 5; zygospores 82—106 μ diameter, 141—202 μ long ..20. *S. elliptica*
- 18-Vegetative cells between 73—90 μ diameter; zygospores between 57—74 μ diameter19
- 19-Zygospores cylindric-ellipsoid, ends rounded; 4 chromatophores, sometimes 3 or 218. *S. szechwanensis*
- 19-Zygospores ellipsoid, ends pointed; 3—5 chromatophores19. *S. nitida*
- 20-Chromatophore one (rarely two in some cells)21
- 20-Chromatophores more than one23
- 21-Both sterile and fertile cells cylindrical; punctate zygospores obovoid in form21. *S. obovata*
- 21-Both sterile and fertile cells inflated; punctate or reticulate zygospores ellipsoid in form22
- 22-Vegetative cells 22—26 μ diameter; mesospore punctate22. *S. subpapulata*
- 22-Vegetative cells 28—32 μ diameter; mesospore reticulate23. *S. papulata*
- 23-Mesospore of one layer24
- 23-Mesospore of two layers26
- 24-Vegetative cells 25—32 μ diameter; 2—3 (—4) chromatophores; fertile cells enlarged by the zygospores25
- 24-Vegetative cells 40—45 μ diameter; 3—5 chromatophores; fertile cells cylindrical ...26. *S. rhizobrachialis*
- 25-Zygospores cylindric-ellipsoid, 32—39 μ diameter24. *S. subcylindrospora*
- 25-Zygospores obovoid, 41—55 μ diameter25. *S. dictyospora*
- 26-Fertile cells inflated27
- 26-Fertile cells enlarged by the zygospores ..28
- 27-Vegetative cells 22—26 μ diameter; 3 chromatophores; zygospores 35—39 μ diameter ..27. *S. chungkingensis*
- 27-Vegetative cells 41—58 μ diameter; 4 or 3 chromatophores; zygospores 54—64 μ diameter30. *S. pulchrifigurata*
- 28-Vegetative cells 38—58 μ diameter; fertile cells cylindrical, in series; zygospores ellipsoid; inner mesospore punctate28. *S. quadrilaminata*

- 28-Vegetative cells 29—41 μ diameter; fertile cells enlarged by the zygospores, mostly solitary; zygospores obovoid, 51—58 μ diameter; inner mesospore coarsely reticulate..29. *S. corrugata*
- 29-Spore wall smooth30
- 29-Spore wall not smooth42
- 30-One chromatophore in each cell31
- 30-More than one chromatophores in each cell..41
- 31-Fertile cells cylindrical or enlarged by pressure of the zygospores32
- 31-Fertile freely inflated36
- 32-Vegetative cells between 16—19 μ in diameter33
- 32-Vegetative cells between 20—32 μ in diameter34
- 33-Sterile cells cylindrical; zygospores cylindric-obovoid or obovoid31. *S. arta*
- 33-Sterile cells cylindrically inflated; zygospores ellipsoid32. *S. tumida*
- 34-Zygospores ellipsoid, between 32—46 μ diameter35
- 34-Zygospores obovoid, 26—32 (—35) μ diameter33. *S. Weberi*
- 35-Zygospores cylindric-ellipsoid, with pointed ends; epispore thick and lamellose35. *S. lamellosa*
- 35-Zygospores ellipsoid, with rounded ends; epispore thin and not lamellose34. *S. semiornata*
- 36-Fertile cells inflated on the conjugating side37
- 36-Fertile cells inflated on both side38
- 37-Vegetative cells 16—19 μ diameter; zygospores 27—35 μ diameter40. *S. Spreetiana*
- 37-Vegetative cells 26—29 μ diameter; zygospores 32—48 μ diameter41. *S. hopeiensis*
- 38-Conjugation tubes formed by both male and female gametangia39
- 38-Conjugation tubes formed by male gametangia only40
- 39-Vegetative cells 9—13 μ diameter; zygospores 24—29 μ diameter36. *S. tenuissima*

- 39—Vegetative cells 18—23 μ diameter; zygo-spores 27—34 μ diameter37. *S. inflata*
- 40—Vegetative cells 13—16 μ diameter; fertile cells mostly cylindrically inflated; zygo-spores 22—34 μ in diameter38. *S. cylindrica*
- 40—Vegetative cells 28—39 μ diameter; fertile cells fusiformly inflated; zygosporos 35—43 μ diameter39. *S. Chuniae*
- 41—Vegetative cells 32—35 μ diameter; 2 chromatophores; zygosporos 38—45 μ diameter42. *S. Hassalli*
- 41—Vegetative cells 42—58 μ diameter; 2—3 chromatophores; zygosporos 41—58 μ diameter43. *S. Transeauiana*
- 42—Vegetative cells less than 28 μ in diameter; one chromatophore43
- 42—Vegetative cells between 32—45 μ in diameter; 2 or 1—2 chromatophores47
- 43—Inner epispore deeply scrobiculate; mesospore smooth49. *S. venusta*
- 43—Mesospore with various markings; epispore not scrobiculate44
- 44—Mesospore granulate47. *S. microgranulata*
- 44—Mesospore reticulate45
- 45—Zygosporos ellipsoid46
- 45—Zygosporos obovoid45. *S. laxistrata*
- 46—Vegetative cells 13—16 μ diameter; mesospore reticulate44. *S. foveolata*
- 46—Vegetative cells 19—26 μ diameter; mesospore denticulately reticulate46. *S. dentireticulata*
- 47—Vegetative cells 32—35 μ diameter; 2 chromatophores; inner mesospore granulate48. *S. granulata*
- 47—Vegetative cells 32—40 μ diameter; one chromatophore, or sometimes two; inner epispore deeply scrobiculate50. *S. Cleveana*
- 47—Vegetative cells 41—45 μ diameter 2 chromatophores; inner mesospore coarsely reticulate51. *S. quinquilaminata*

1. *Spirogyra Liana* Transeau 1934

(Pl. IV, figs. 48, 49)

Vegetative cells $13\text{--}16\mu$ diameter, $42\text{--}110\mu$ long, with plane end walls; one chromatophore, making 1—4 turns in the cell; conjugation scalariform or lateral; conjugation tubes formed by the male gametangia only; fertile cells inflated, from $29\text{--}32\mu$ in diameter, usually 1—5 cells separated by one or several non-conjugating cells; zygospores ellipsoid, $22\text{--}29\mu$ diameter, $35\text{--}50\mu$ long; spore wall smooth, yellow at maturity.

This local form has the vegetative cells a little larger than the type and the conjugation is not wholly scalariform.

In a rice farm near Lung-Yin-Ch'ang, Dec., 1933 (S118).

2. *Spirogyra gibberosa*, sp. nov.

(Pl. IV, figs. 50, 51)

Cellulis vegetativis $19\text{--}21\mu$ latis, $48\text{--}140\mu$ longis, dissepimentis planis; chromatophoris singulis, anfractibus 2—8; conjugatione scalari, interdum laterali; tubo conjugationis omnino ex cellula mascula emisso; cellulis fructiferis ad tubos conjugationis versus exstatis, $29\text{--}40\mu$ latis, saepe zygospora maturata inter se disjunctibus; zygosporis ellipsoideis, apice plus minusve acuminatis, $22\text{--}29\mu$ latis, $38\text{--}50\mu$ longis, membrana laevi, maturitate flavescente.

Vegetative cells $19\text{--}21\mu$ diameter, $48\text{--}140\mu$ long, with plane end walls; one chromatophore, making 2—8 turns in the cell; conjugation scalariform, sometimes lateral; conjugation tubes formed wholly by the male gametangium; fertile cells inflated on the conjugating side, from 29 to 45μ in diameter, often separating from each other as the zygospores near maturity; zygospores ellipsoid, with more or less pointed ends, $22\text{--}29\mu$ diameter, $38\text{--}50\mu$ long, spore wall smooth, yellow at maturity.

This new species is near *Spirogyra Liana* Transeau and the new species described in this paper as *S. Chenii*. It differs from them by its fertile cells inflating on the conjugating side,

later separating from each other as the zygosporos near maturity, and not regularly interrupted by non-conjugating cells.

In rice farms, Li-Tze-Pa (S689) and Niu-Kioh-To (S696), Jan. 1934. Type in C. C. Jao collections and Herb. Univ. Mich., No. S696.

3. *Spirogyra Chenii*, sp. nov.

(Pl. IV, fig. 52)

Cellulis vegetativis $19-22\mu$ latis, $38-115\mu$ longis, dissepimentis planis; chromatophoris singulis, anfractibus 1—5; conjugation plerumque laterali, interdum scalari; tubo conjugationis omnino ex cellula mascula emisso; cellulis fructiferis inflatis, $29-42\mu$ latis, seriebus cellularum 1—5 inter steriles unam usque ad complures dispositis; zygosporis ellipsoidis, apice plus minusve acuminatis, $25-32\mu$ latis, $45-61\mu$ longis; membrana laevi, maturitate flavescenti.

Vegetative cells $19-22\mu$ diameter, $38-115\mu$ long, with plane end walls; one chromatophore, marking 1—5 turns in the cell; conjugation mostly lateral, sometimes scalariform; conjugation tubes formed by the male gametangia only; the fertile cells inflated from 29 to 42μ in diameter, 1—5 cells in series among one to several non-conjugating cells; zygosporos ellipsoid, with more or less pointed ends, $25-32\mu$ diameter, $45-61\mu$ long; spore wall smooth, yellow at maturity.

This new species is characterized by larger dimensions of all its cells and its mostly lateral conjugation to differentiate it from *Spirogyra Liana* Transeau.

In rice farms, Lung-Yin-Ch'ang, Dec., 1933 (S136 and S137); in a pond near Hsian-Kuo-Shih, Dec. 27, 1933 (S578); in a well near Liu-Chia-Tan, Dec. 27, 1933 (S555); in rice farms, Hsiao-Lung-Kan (S642) and Niu-Kioh-To (S753), Nov. 1934. Type in C. C. Jao collections and Herb. Univ. Mich., No. S753.

4. *Spirogyra fennica* Cedercreutz 1924

(Pl. IV, fig. 53)

Vegetative cells $16-19\mu$ diameter, (32—) $46-120\mu$ long, with plane end walls, one chromatophore, very rarely two,

making 2—5 turns in the cell; conjugation mostly lateral, sometimes scalariform; conjugation tubes formed by both male and female cells; fertile cells inflated on both sides, with diameter from 29 to 35μ ; zygospores ellipsoid, with pointed ends, 22— 29μ diameter, 41— 58μ long; spore wall smooth, yellow at maturity.

This local form has measurements and habits very close to Cedercreutz's description, but its conjugation is not only scalariform, lateral conjugation being more frequent than scalariform.

In rice farms, Sha-P'in-Pa, Nov. 11, 1934 (S648); Li-Tze-Pa, Jan., 1934 (S669); Lung-Yin-Ch'ang, Dec., 1933 (S104 and S107); near Liu-Chia-T'an, Oct., 1933 (S408).

5. *Spirogyra communis* (Hassall) Kützing 1849

(Pl. IV, fig. 54)

Filaments bright green; vegetative cells 19— 22μ diameter 64— 128μ long, with plane end walls; one chromatophore, making 2.5—5 turns in the cell; conjugation scalariform; fertile cells cylindrical; zygospores ellipsoid, with more or less pointed ends, 18— 21μ diameter, 35— 51μ long; spore wall smooth, yellow at maturity.

The dimensions of this local form are a little smaller than those of the typical plant.

In a stony pool near Hsian-Kuo-Shih, Dec., 1934 (S582).

6. *Spirogyra bullata*, sp. nov.

(Pl. IV, fig. 55)

Cellulis vegetativis 19— 22μ latis, 41— 83μ longis, dissepimentis planis; chromatophoris singulis, anfractibus 1.5—5.5; conjugatione scalari; cellulis sterilibus valde bullatis, plerumque globosis vel subglobosis, raro obovoideis, latitudine usque ad 64μ , 1—25 turbis collectis; cellulis fructiferis cylindricis vel zygospora paululum inflatis; zygosporis ellipsoideis, apice plus minusve rotundatis, 22— 29μ latis, 31— 35μ longis; membrana laevi, maturitate flavescente.

Vegetative cells 19—22 μ diameter, 41—83 μ long, with plane end walls; chromatophore one, making 1.5—5.5 turns in the cell; conjugation scalariform; sterile cells in conjugating filaments greatly bullate, mostly globose or subglobose, rarely obovoid, with the diameter up to 64 μ , in groups of 1—25 cells; fertile cells cylindrical or slightly enlarged by the zygospore; zygospores ellipsoid, with more or less rounded ends, 22—29 μ diameter, 31—35 (—51) μ long; spore wall smooth, yellow at maturity.

This species is nearest to *Spirogyra pratensis* Transeau, but differs from it in having smaller dimensions of the zygospores, in having larger diameter and shorter length of the vegetative cells, in having the fertile cells cylindrical or slightly enlarged, and in having the bullate sterile cells of the fruiting filaments mostly in groups of many together.

In rice farms, near Chungking, Aug. 1930 (S270 and S271). Filaments scattered among many other filamentous algae, such as *Spirogyra Juergensii* Kützing, *S. corrugata* Transeau, *S. quadrilaminata* Jao, *S. chungkingense* Jao, *Oedogonium spiralidens* Jao, *Oe. costatosporum* Jao, *Oe. excavatum* Jao, etc. Type in C. C. Jao collections and Herb. Univ. Mich., No. S270.

7. *Spirogyra polymorpha* Kirchner 1878, f.

(Pl. V, figs. 56, 57)

Vegetative cells 22—25 μ diameter, 61—192 μ long, with plane end walls; one chromatophore, making 1—6.5 turns in the cell; reproduction by zygospores or parthenospores; conjugation scalariform; conjugation tubes formed by both male and female gametangia; fertile cells inflated up to 65 μ diameter; sterile cells sometimes inflated, with the diameter up to 64 μ ; zygospores polymorphic, globose, subglobose, obovoid and ellipsoid zygospores occurring on same filament, 22—32 μ diameter, 25—35 μ long; spore wall smooth, yellow at maturity.

These local plants have inflated fertile cells, tumid sterile cells and the zygospores very irregular in form and size.

Perhaps to name them *Spirogyra polymorpha* Kirchner is correct, but they differ from the typical form, as they have rather smaller vegetative cells and sometimes the sterile cells become inflated.

In a rice farm, Nan-Shan, Jan., 1932 (S331).

8. *Spirogyra fragilis*, sp. nov.

(Pl. VI, fig. 64)

Cellulis vegetativis 24—29 μ latis, 54—160 μ longis, dissepimentis planis; chromatophoris singulis, raro 2, anfractibus 1.5—6; conjugatione scalari; cellulis fructiferis paulo inflatis praesertim tubos versus; gametangiis feminis post conjugium plerumque inter se disjungentibus; zygosporis ellipsoideis, apice plus minusve rotundatis, 22—38 μ latis, 36—67 μ longis, membrana laevi, maturitate flavescenti.

Vegetative cells 24—29 μ diameter, 54—160 μ long, with plane end walls; one chromatophore, rarely two, making 1.5—6 turns in the cell; conjugation scalariform; fertile cells slightly inflated, usually a little more on the conjugation side; the female gametangia often separating from each other after conjugation; zygosporoes ellipsoid, with more or less rounded ends, 22—38 μ diameter, 36—67 μ long, spore wall smooth, yellow at maturity.

This species is near *Spirogyra Teodoresci* Transeau MSS., but differs from it chiefly in having the fertile cells only slightly inflated on conjugating side.

In rice farms: Fou-Tu-Kuan, Jan. 2, 1933 (S461); Liu-Tien-Tze, Jan., 1933 (S487: 1); Sha-P'in-Pa, Nov. 11, 1934 (S648). Type in C. C. Jao collections and Herb. Univ. Mich., No. S461.

9. *Spirogyra intorta* Jao 1935

(Pl. V, fig. 58)

Vegetative cells 25—29 μ diameter, 60—183 μ long, generally curved or spiral, with plane end walls; one chromatophore,

making 3.5—6 turns in the cell; conjugation scalariform or lateral (?); fertile cells cylindrical, sometimes slightly swollen; zygospores ellipsoid, with pointed ends, 22—29 μ diameter, 41—68 μ long; spore wall smooth, yellow at maturity.

This species is near *Spirogyra Juergensii* Kützing and *S. communis* (Hassall) Kützing, but is distinguished from the first in having fertile cells not enlarged toward the middle and in having smaller zygospores, and from both in having constantly curved or spiral filaments.

In rice farms at Shao-Chia-Wan, June 10, 1933 (S497 and S503).

10. *Spirogyra Juergensii* Kützing 1843

(Pl. V, fig. 59)

Vegetative cells 25—30 μ diameter, 42—80 μ long, with plane end walls; one chromatophore, making 2—2.5 turns in the cell; conjugation scalariform; conjugation tubes formed equally by both gametangia; fertile cells enlarged toward the middle to contain the zygospore; zygospores ellipsoid, with more or less rounded ends, 28—31 μ diameter, 42—64 μ long; spore wall smooth, yellow at maturity.

In rice farms near Chungking, Aug. 1930 (S270: 013 and S6).

11. *Spirogyra Borgeana* Transeau 1915

(Pl. V, fig. 60)

Filaments deep green; vegetative cells 28—35 μ diameter, 48—128 μ long, with plane end walls; one chromatophore, broad, making 0.5—3 turns in the cell; conjugation scalariform; fertile cells clearly inflated on the outer side, sometimes slightly on the conjugation side; zygospores ellipsoid, 30—38 μ diameter, 48—67 μ long; spore wall smooth, yellow at maturity.

This species is very well characterized by its fertile cells inflated on the outer side, which distinguishes it from all others except *Spirogyra calcarea* Transeau, which is larger than this species.

In a rain pool on the bank of Chialing River near Hochuan City, Aug. 1, 1933 (S466).

12. *Spirogyra longata* (Vaucher) Kützing 1843

(Pl. V, fig. 61)

Vegetative cells $26-35\mu$ diameter, $42-140\mu$ long, with plane end walls; one chromatophore, making 1.5—5 turns in the cell; conjugation scalariform; conjugation tubes equally contributed by male and female gametangia; fertile cells cylindrical; zygospores obovoid to cylindric-obovoid; with broad rounded ends, $27-32\mu$ diameter, $45-88\mu$ long; aplanospores similar in the form to the zygospores, very rare, $28-29\mu$ diameter, $35-42\mu$ long; spore wall smooth, yellow at maturity.

In rice farms: Fou-Tu-Kuan, Feb., 1932 (S300, S311 and S323); Li-Tze-Pa, Nov. 20, 1933 and Jan., 1934 (S682 and S690).

13. *Spirogyra singularis* Nordstedt 1888

(Pl. V, fig. 62)

Vegetative cells $29-36\mu$ diameter, $42-110\mu$ long, with plane end walls; one chromatophore, broad, containing large pyrenoids, making 1.5—5 turns in the cell; conjugation scalariform; fertile cells cylindrical or slightly enlarged by the zygospores; zygospores ellipsoid, with more or less rounded ends, $28-40\mu$ diameter, $52-70\mu$ long, mesospore smooth, yellow at maturity.

This species is separated from *Spirogyra Juergensii* Kützing by its larger size.

In a rice farm near Chungking, Jan., 1933 (S454 and S458).

14. *Spirogyra varians* (Hassall) Kützing 1849

(Pl. V, fig. 63)

Vegetative cells (26—) $29-36\mu$ diameter, $40-120\mu$ long, with plane end walls; one chromatophore, making 2—6 turns in

the cell; conjugation scalariform; fertile cells inflated on the conjugating side only, $40\text{--}48\mu$ diameter, sometimes shorter than the vegetative cells; sterile cells greatly inflated, up to 65μ in diameter; zygospores ellipsoid, with pointed ends in the normal condition, $26\text{--}36\mu$ diameter, $35\text{--}50\mu$ long, spore wall smooth, yellow at maturity.

These plants are very abundant in the writer's collections from Szechwan. All of them have dimensions somewhat smaller than in some former descriptions of American, European or South American forms. In De Toni's form of the description, the vegetative cells are reported $33\text{--}47\mu$ diameter, 1—3 diameters long and zygospores $33\text{--}38\mu$ diameter, 1.5—2.5 diameters long. In Collins' "Green Algae of North America" the vegetative cells are considered only $33\text{--}40\mu$ diameter and 2—3 diameters long. In 1930, Czurda reported these plants, under the name *S. varians* (Kützing) Czurda, having the vegetative cells $28\text{--}32\mu$ diameter, zygospores $24\text{--}37\mu$ diameter and $38\text{--}56\mu$ long. In Kützing's original description no measurements of vegetative cells and zygospores are mentioned. Considering these different measurements, Czurda's diagnosis to be nearest to these Chinese plants. This species is widely distributed in many countries and seems very variable in measurements. It is clearly characterized by the swollen sterile cells, the fertile cells inflated on the conjugating side, one chromatophore, and ellipsoid or sometimes obovoid zygospores having a smooth wall as the bases which associate it with the name *S. varians* (Hassall) Kützing.

In a small stony pool, near Hsian-Kuo-Shih, Dec. 12, 1933 (S382: 3); in a well, Sha-P'in-Pa, Nov. 17, 1934 (S658); in a rice farm, Niu-Kioh-To, Dec. 12, 1934 (S666 and S667); in rice farms, Li-Tze-Pa, Nov. 1933 and Jan., 1934 (S690 and S670); in a rice farm near Fou-Tu-Kuan, Jan., 1934 (S676).

15. *Spirogyra microspora*, sp. nov.

(Pl. VI, fig. 65)

Cellulis vegetativis $35\text{--}38\mu$ latis, $64\text{--}131\mu$ longis, dissepimentis planis; chromatophoris 2, latis, pyrenoideis grandibus,

anfractibus 1.5—3.5; conjugatione laterali; cellulis fructiferis cylindricis; zygosporis ellipsoideis, apice plus minusve rotundatis, 29—32 μ latis, 51—61 μ longis, membrana laevi, maturitate flavescenti.

Vegetative cells 35—38 μ diameter, 64—131 μ long, with plane end walls; 2 chromatophores, broad, pyrenoids large, making 1.5—3.5 turns in the cell; conjugation lateral; fertile cells cylindrical; zygosporis ellipsoid, with more or less rounded ends, 29—32 μ diameter, 51—61 μ long, spore wall smooth, yellow at maturity.

This species is characterized by the cylindrical female gametangia containing small zygosporis and the chromatophores regularly two, which distinguish from the related species *S. irregularis* Naegeli and *S. submarina* (Collins) Transeau.

In a rice farm near Lung-Yin-Ch'ang, Nov., 1933. Type in C. C. Jao collections and Herb. Univ. Mich., No. S152.

16. *Spirogyra decimina* (Müller) Kützing 1843

(Pl. VI, fig. 66)

Vegetative cells 35—42 μ diameter, 65—150 μ long, with plane end walls; 2—3 chromatophores, making 2.5—3 turns in the cell; conjugation scalariform; fertile cells cylindrical or slightly enlarged by the zygosporis; the female gametangia occasionally separating from each other after conjugation; zygosporis obovoid or sometimes subglobose, 35—37 μ diameter, 37—73 μ long, spore wall smooth, yellow at maturity.

These plants were found abundantly in rice farms near Chungking, forming large dark-green masses floating on the water surface, Jan. to Feb., 1933 (S266—S269).

17. *Spirogyra biformis* Jao 1935

(Pl. VI, fig. 67, 68)

Vegetative cells 38—48 μ diameter, 46—150 (—190) μ long, with plane end walls; 2—3 chromatophores, making 1.5—4.5 turns in the cells; sterile cells sometimes inflated to 58 μ in

diameter; fertile cells cylindrical or sometimes slightly enlarged by the zygospore, shortened or not; conjugation usually lateral, rarely scalariform; zygospores ellipsoid and with rounded ends, $38\text{--}51\mu$ diameter, $64\text{--}83\mu$ long; mesospore smooth, yellow at maturity.

This species is nearest to *Spirogyra rivularis* (Hassall) Rabenhorst, but differs from it in the broader and shorter vegetative cells, the sterile cells sometimes swollen, and the zygospores not oval-ellipsoid in form.

In rice farms near Chungking, July, 1930 (S260, S262 and S272).

18. *Spirogyra szechwanensis* Jao 1935

(Pl. VI, fig. 69)

Vegetative cells $75\text{--}90\mu$ diameter, $125\text{--}240\mu$ long, with plane end walls; 4 chromatophores, rarely 2 or 3, making 1—2 turns in the cell; fertile cells cylindrical; conjugation scalariform; zygospores cylindric-ellipsoid, with more or less rounded ends, $57\text{--}68\mu$ diameter, $100\text{--}210\mu$ long, spore wall smooth, yellow at maturity.

This species is characterized by its smaller vegetative cells not contracted at the ends and zygospores having a smaller diameter, greater length, and cylindric-ellipsoid in form which distinguish it from the related species *S. jugalis* (Dillwyn) Kützing.

In a rice farm near Chungking, 1930 (S70: B).

19. *Spirogyra nitida* (Dillwyn) Link 1833

(Pl. VI, fig. 70, 71)

Filaments deep green; vegetative cells $73\text{--}84\mu$ diameter, $133\text{--}245\mu$ long, with plane end walls; 3—5 chromatophores, slender, with small pyrenoids and nearly straight margins, making 3—5 turns in the cell; conjugation scalariform; fertile cells cylindrical; zygospores mostly ellipsoid, rarely cylindric-ellipsoid, with more or less pointed ends, $58\text{--}74\mu$ diameter, $105\text{--}189\mu$ long, mesospore smooth, yellow at maturity.

In rice farms near Chungking, Feb., 1932 (S316 and S329).

20. *Spirogyra elliptica*, sp. nov.

(Pl. VI, fig. 72)

Cellulis vegetativis $115-128\mu$ latis, $128-568\mu$ longis, dissepimentis planis; chromatophoris 4 vel 6, anfractibus 1—3; conjugatione scalari; cellulis fructiferis cylindricis et aliquantum contractis; zygosporis ellipsoideis, non compressis, apice acuminatis; $82-106\mu$ latis, $144-202\mu$ longis, membrana laevi, maturitate fuscescenti.

Vegetative cells $115-128\mu$ diameter, $128-568\mu$ long, with plane end walls; 4—6 chromatophores, making 1—3 turns in the cell; conjugation scalariform; fertile cells cylindrical and somewhat shortened; zygosporis ellipsoid, not compressed, with pointed ends; $82-106\mu$ diameter, $144-202\mu$ long, spore wall smooth, yellowish brown at maturity.

This species is nearest to *Spirogyra setiformis* (Roth) Kützing and *S. hatillensis* Transeau MSS, but differs from the first in having larger vegetative cells and zygosporis and the chromatophores mostly 6 in number, and from the second in having the chromatophores not more than 6 and the zygosporis being smaller in diameter and greater in length.

In rice farms, Li-Tze-Pa, Jan., 1933 (S683 and S701). Type in C. C. Jao collections and Herb. Univ. Mich., No. S701.

21. *Spirogyra obovata*, sp. nov.

(Pl. VII, fig. 73)

Cellulis vegetativis $25-29\mu$ latis, $70-182\mu$ longis, dissepimentis planis; chromatophoris singulis, raro 2, anfractibus $2.5-6$; conjugatione scalari; cellulis fructiferis cylindricis vel zygospora paululum inflatis; generationibus zygosporis vel aplanosporis ortis; zygosporis obovoideis, $29-35\mu$ latis, $55-73\mu$ longis; aplanosporis zygosporis conformantibus, $29-32\mu$ latis, $38-42\mu$ longis; mesosporio punctato, maturitate flavescenti.

Vegetative cells $25\text{--}29\mu$ diameter, $70\text{--}182\mu$ long, with plane end walls; one chromatophore, rarely two, making 2.5—6 turns in the cell; reproduction by both zygosporos and aplanosporos; conjugation scalariform; fertile cells cylindrical or very slightly enlarged by the zygosporos; zygosporos obovoid, $29\text{--}35\mu$ diameter, $55\text{--}73\mu$ long; aplanosporos shorter than the zygosporos but otherwise of the same form, $29\text{--}32\mu$ diameter, $38\text{--}42\mu$ long; mesospore punctate, yellow at maturity.

This new species is characterized by its obovoid punctate zygosporos and its measurements, which distinguish it from the former species, which possesses one chromatophore and a mesospore with markings.

In a rice farm near Niu-Kioh-To, Nov. 15, 1933 (S727). Type in C. C. Jao collections and Herb. Univ. Mich., No. S727.

22. *Spirogyra subpapulata*, sp. nov.

(Pl. VII, figs. 74, 75)

Cellulis vegetativis $22\text{--}26\mu$ latis, $41\text{--}166\mu$ longis, dissepimentis planis; chromatophoris singulis, anfractibus 2—7; generationibus zygosporis vel aplanosporis ortis; conjugatione scalariformi; cellulis sterilibus plerumque tumidis, latitudine usque ad 58μ ; cellulis fructiferis uno latre (in quo conjugatio sequitur) inflatis ad latitudinem 38μ ; zygosporis ellipsoideis, apice acuminatis, $21\text{--}29\mu$ latis, (32—) $41\text{--}61\mu$ longis; aplanosporis subglobosis vel ellipsoideis, $22\text{--}26\mu$ latis, $32\text{--}48\mu$ longis; mesosporio leviter et dense punctato, maturitate flavescenti.

Vegetative cells $22\text{--}26\mu$ diameter, $41\text{--}166\mu$ long, with plane end walls; one chromatophore, making 2—7 turns in the cell; reproduction by either zygosporos or aplanosporos; conjugation scalariform; sterile cells usually swollen to 58μ in diameter; zygosporos ellipsoid, with pointed ends, $21\text{--}29\mu$ diameter, (32—) $41\text{--}60\mu$ long; aplanosporos subglobose or ellipsoid, $22\text{--}26\mu$ diameter, $32\text{--}48\mu$ long; mesospore finely and densely punctate, yellow at maturity.

This species bears characteristics very close to *Spirogyra papulata* Jao, excepting its smaller vegetative cells and punctate mesospore.

In a pond near Hsian-Kuo-Shih, Dec. 27, 1933 (S578); in a rice farm near Niu-Kioh-To, Jan., 1934 (S696); in a well near Tseng-Chia-Yen, Dec. 14, 1933 (S708). Type in C. C. Jao collections and Herb. Univ. Mich., No. S587.

23. *Spirogyra papulata* Jao 1935

(Pl. VII, fig. 76—78)

Vegetative cells 28—32 μ diameter, 64—176 μ long, with plane end walls; one chromatophore, making 1—4.5 turns in the cell; conjugation scalariform or lateral; fertile cells usually shortened and inflated on the conjugating side, reaching 55 μ in diameter; sterile cells sometimes swollen to 64 μ ; zygospores ellipsoid, with more or less rounded ends, 22—32 μ diameter, 35—55 μ long, mesospore irregularly reticulate, golden yellow at maturity.

This species probably is related to *Spirogyra scrobiculata* (Stockmayer) Czurda, but this Chinese plants is quite clearly distinguished from it by the reticulate zygospores and the rather narrower vegetative cells.

In a rice farm near Chiangpei City, Jan., 1933 (S414: S1).

24. *Spirogyra subcylindrospora* Jao 1935

(Pl. VII, figs. 79, 80)

Vegetative cells 25—32 μ diameter, 98—228 μ long, with plane end walls; 2—3 chromatophores, rarely 4, making 1—5.5 turns in the cell; conjugation scalariform; fertile cells cylindrical or slightly enlarged by the zygospores; zygospores ellipsoid, or cylindric-ellipsoid, with rounded ends, 32—39 μ diameter, 57—69 μ long; mesospore reticulate, yellowish brown at maturity.

This species differs from *Spirogyra dictyospora* Jao in having the zygospores ellipsoid in form and smaller in size.

In rice farms near Chungking, Aug., 1930 (S259 and S265).

25. *Spirogyra dictyospora*, sp. nov.

(Pl. VIII, fig. 84)

Cellulis vegetativis $28\text{--}32\mu$ latis, $55\text{--}144\mu$ longis, dissepimentis planis; chromatophoris 3, vel interdum 2, anfractibus 2—5; conjugatione scalari; cellulis fructiferis zygospora inflatis, latitudine usque ad 55μ ; zygosporis obovoidis, $41\text{--}55\mu$ latis, $61\text{--}103\mu$ longis; mesosporio irregulariter reticulato, maturitate flavescenti vel fusciscenti.

Vegetative cells $28\text{--}32\mu$ diameter, $55\text{--}144\mu$ long, with plane end walls; 3 chromatophores, sometimes 2, making 2—5 turns in the cell; conjugation scalariform; fertile cells enlarged by the zygosporis, with the diameter up to 55μ ; zygosporis obovoid, $41\text{--}55\mu$ diameter, $61\text{--}103\mu$ long, mesospore irregularly reticulate, yellow to yellowish brown at maturity.

This species is near *Spirogyra aequinoctialis* G. W. West, but distinguished from it in having greater dimensions of all cells and in having the zygosporis with an irregularly reticulate mesospore. It differs from *S. subcylindrospora* Jao in having the zygosporis obovoid in form and greater in size.

In a rice farm near Chungking, Feb., 1930 (S264). Type in C. C. Jao collections and Herb. Univ. Mich., No. S264.

26. *Spirogyra rhizobrachialis* Jao 1935

(Pl. VII, figs. 81—83)

Vegetative cells $40\text{--}45\mu$ diameter, $144\text{--}240\mu$ long, with plane end walls; 3—5 chromatophores, making 1.5—2.5 turns in the cell; in some portions of the filaments each sterile cell laterally producing one rhizoid-shaped attachment with more or less lobed hapteron; conjugation scalariform; fertile cells cylindrical, sometimes shortened and enlarged by the zygosporis; zygosporis ellipsoid, with more or less rounded ends, $38\text{--}53$ ($\text{--}61$) μ diameter, (58--) $64\text{--}100\mu$ long; mesospore finely and irregularly reticulate, yellowish brown at maturity.

This species is near *Spirogyra paraguayensis* Borge and *S. subreticulata* Fritsch, but differs from the first in having

smaller vegetative cells, the zygospores not oblong-ellipsoid in form, and from both in having the sterile cells very often laterally producing rhizoid-shaped attachments.

In rice farms near Chungking, Aug., 1930 (S256, S259 and S265).

27. *Spirogyra chungkingensis* Jao 1935

(Pl. VIII, figs. 85, 86)

Vegetative cells $22-26\mu$ diameter, $80-170\mu$ long, with plane end walls; 3 chromatophores, making 1—3 turns in the cell; conjugation scalariform; fertile cells inflated; zygospores ellipsoid, with more or less rounded ends, $35-39\mu$ diameter, $54-68\mu$ long; spore wall of four layers, epispore colorless and thin, outer mesospore brownish, with more or less densely longitudinal and wavy lines, inner mesospore brown and finely and irregularly reticulate, endospore thin and smooth.

This species is near *Spirogyra orientalis* W. & G. S. West, from which it differs in the smaller diameter of the vegetative cells and zygospores and the four-layered spore wall. In zygospore characteristics it is like *S. quadrilaminata* Jao, but *S. chungkingensis* is smaller in dimensions, the chromatophores are constantly 3, and the fertile cells are inflated. It also bears some resemblances to *S. subcylindrospora* Jao, but differs from it in having smaller vegetative cells, the four-layered spore wall and the chromatophores constantly 3 in number.

In a rice farm near Chungking, Aug., 1930 (S270).

28. *Spirogyra quadrilaminata* Jao 1935

(Pl. VIII, figs. 87, 88)

Vegetative cells $38-58\mu$ diameter, $112-250\mu$ long, with plane end walls, 3—4 chromatophores, making 1—3.5 turns in the cell; fertile cells cylindrical; conjugation scalariform; zygospores ellipsoid to cylindric-ellipsoid, with more or less rounded ends, $45-55\mu$ diameter, $64-102\mu$ long; spore wall of four layers, epispore colorless, outer mesospore brown, more or less

closely and longitudinally wrinkled, inner mesospore brown, finely punctate, sometimes finely and irregularly reticulate, endospore thin and smooth.

This species is especially characterized by the four-layered spore wall, which distinguishes it from the related species *S. subreticulata* Fritsch.

In a rice farm near Chungking, Aug., 1930 (S270: 06).

29. *Spirogyra corrugata* Transeau 1934

(Pl. VIII, figs. 89, 90)

Vegetative cells 29—42 μ diameter, (112—) 250—512 μ long, with plane end walls; chromatophores mostly 2—3, rarely 1 or 4 or 5, making 2—5 turns in the cell; conjugation scalariform; conjugation tubes formed wholly by the male gametangia; fertile cells inflated and shortened; zygospores obovoid, 51—58 μ diameter, 86—122 μ long; spore wall of four layers, outer mesospore yellow and irregularly wrinkled, inner mesospore brownish yellow and coarsely and irregularly reticulate, usually with a wide space between outer and inner mesospore, especially on both ends of the zygospores, endospore distinct.

This species is clearly characterized by the conjugation tubes wholly formed by the male gametangia, the fertile cells are mostly solitary, and especially the characters of spore wall, which evidently separate it from other species.

In rice farms near Chungking, Aug., 1930 (S259, S270 and S271).

30. *Spirogyra pulchrifigurata* Jao 1935

(Pl. VIII, figs. 91, 92)

Vegetative cells 41—58 μ diameter, 64—192 μ long, with plane end walls; 4 or 3 chromatophores, making 1.5—4 turns in the cell; conjugation scalariform; fertile cells inflated and sometimes shortened, reaching a diameter of 84 μ zygospores ellipsoid, with more or less rounded ends, (51—) 54—64 μ diameter, (61—) 70—109 μ long; mesospore loosely and irregularly reticulate, yellowish brown at maturity.

This species is near *S. brunnea* Czurda, but differs from it in having smaller vegetative cells, larger zygospores and fertile cells mostly strongly inflated on the conjugating side and less so on the outer side.

In a rice farm near Chungking, Feb., 1930 (S264: S1 and S2).

31. *Spirogyra arta*, sp. nov.

(Pl. VIII, fig. 93)

Cellulis vegetativis $16\text{--}18\mu$ latis, $105\text{--}350\mu$ longis, dissepimentis replicatis; chromatophoris singulis, anfractibus 3—8; conjugatione scalariformi; cellulis fructiferis zygospora plus minusve inflatis; zygosporis obovoideis vel cylindrico-obovoideis, $20\text{--}26$ ($\text{--}32$) μ latis, $51\text{--}103\mu$ longis, membrana laevi, maturitate flavescenti.

Vegetative cells $16\text{--}18\mu$ diameter, $105\text{--}350\mu$ long, with replicate end walls; one chromatophore, making 3—8 turns in the cell; conjugation scalariform; fertile cells more or less inflated by the zygospores; zygospores obovoid to cylindric-obovoid, $22\text{--}26$ ($\text{--}32$) μ diameter, $51\text{--}103\mu$ long, spore wall smooth, yellow at maturity.

These plants have much smaller vegetative cells which differentiate it from *S. Weberi* Kützing. The writer has carefully measured many filaments of this species; they constantly show the vegetative cells not more than 18μ in diameter. Based upon this, these plants seem better separated from *S. Weberi* Kützing, even though the measurements and form of the zygospores and growth habit are precisely like.

In a rice farm near Lung-Yin-Ch'ang, Dec., 1933 (S132); in a pond near Hsian-Kuo-Shih, Dec. 27, 1933 (S578); in a stony pool near Liu-Chia-Tan, Dec. 27, 1933 (S588); in a rice farm, Li-Tze-Pa, Jan., 1934 (S681). Type in C. C. Jao collections and Herb. Univ. Mich., No. S588.

32. *Spirogyra tumida*, sp. nov.

(Pl. IX, fig. 96)

Cellulis vegetativis $16\text{--}19\mu$ latis, $85\text{--}175\mu$ longis, dissepimentis replicatis; chromatophoris singulis, anfractibus 3—9;

cellulis sterilis plerumque cylindricis vel interdum fusiformis, latitudine usque ad 45μ ; cellulis fructiferis a zygospora inflatis; zygosporis ellipsoideis, $25\text{--}35\mu$ latis, $48\text{--}86\mu$ longis, membrana laevi, maturitate flavescenti.

Vegetative cells $16\text{--}19\mu$ diameter, $85\text{--}175\mu$ long, with replicate end walls; one chromatophore, making 3—9 turns in the cell; conjugation scalariform; sterile cells inflated, mostly cylindrical or sometimes fusiform, with a diameter up to 45μ ; fertile cells enlarged by the zygosporis; zygosporis ellipsoid, $25\text{--}35\mu$ diameter, $48\text{--}86\mu$ long, spore wall smooth, yellow at maturity.

In size this species is close to *Spirogyra arta* Jao, but differs from it in having inflated sterile cells on the fruiting filaments and in having the zygosporis ellipsoid in form.

In a rice farm, Niu-Kioh-To, Jan., 1934 (S696); in a muddy ditch near Shih-Chiao-Ch'ang, Nov. 11, 1933 (S759). Type in C. C. Jao collections and Herb. Univ. Mich., No. S759.

33. *Spirogyra Weberi* Kützing 1843

(Pl. VIII, figs. 94, 95)

Vegetative cells $20\text{--}30\mu$ diameter, $65\text{--}375\mu$ long, with replicate end walls; one chromatophore, slender and loosely spiralled, with large pyrenoids and irregularly toothed margins; reproduction by zygosporis, rarely by aplanosporis; conjugation scalariform; fertile cells usually slightly enlarged by the zygosporis; zygosporis obovoid or cylindric-obovoid, $26\text{--}32$ ($\text{--}35$) μ diameter, $40\text{--}90\mu$ long; aplanosporis globose, subglobose or obovoid, $25\text{--}35\mu$ diameter, $32\text{--}67\mu$ long; spore wall smooth, yellow at maturity.

These plants are widely and abundantly distributed in the rice farms near Chungking and Chiangpei. In several collections the dimensions appear sometimes a little greater than in the typical form or the zygosporis sometimes are nearly ellipsoid in form with broad rounded ends. The aplanosporis were only found on one conjugating filament. This reproductive method seems to be an abnormal condition.

In rice farms near Liu-Chia-Tan, Jan., 1933 (S404, S405, S409, S410, S411 and S414); in rice farms near Shih-Chiao-Ch'ang, Jan., 1933 (S420 and S435); in rice farms near Fou-Tu-Kuan, Jan., 1933 (S448, S458 and S470); in a stony pond near Liu-Chia-Tan, Dec. 27, 1933 (S588); in a rice farm and a stony pool near Hsian-Kuo-Shih, Dec. 27, 1933 (S554 and S582); in rice farms near Lung-Yin-Ch'ang, Dec., 1933 (S109 and S141); in rice farms near Niu-Kioh-To, Jan. and Dec., 1934 (S667 and S699).

34. *Spirogyra semiornata*, sp. nov.

(Pl. IX, figs. 97, 98)

Cellulis vegetativis 27—32 μ latis, 96—245 μ longis, dissepimentis replicatis; chromatophoris singulis, pyrenoideis magnis, anfractibus 2—6; generationibus zygosporis vel raro aplanosporis ortis; conjugatione laterali vel scalari; cellulis fructiferis zygospora paululum inflatis; zygosporis ellipsoideis, apice rotundatis, 35—46 μ latis, 61—106 μ longis; aplanosporis subglobose vel subellipsoideis, 32—38 μ latis, 35—51 μ longis; membrana sporae laevi, maturitate fuscescenti.

Vegetative cells 27—32 μ diameter, 96—245 μ long, with replicate end walls; one chromatophore, containing large pyrenoids, making 2—6 turns in the cell; reproduction by zygosporis or rarely by aplanosporis; conjugation lateral or scalariform; fertile cells slightly enlarged by the zygosporis; zygosporis ellipsoid, with rounded ends, 35—46 μ diameter, 61—106 μ long; aplanosporis subglobose or subellipsoid, 32—38 μ diameter, 35—51 μ long; spore wall smooth, yellowish brown at maturity.

This new species should be compared with *Spirogyra laxa* Kützing and *S. tjibodensis* Faber. It differs, however, from the first chiefly in having the zygosporis with rounded ends and much larger diameters, and from the second in having smaller vegetative cells and larger zygosporis.

These plants are abundantly found in the vicinity of Chungking and Chiangpei. In several collections they show

the conjugation as nearly entirely of the lateral form, the remaining material being both lateral and scalariform. However, all the samples are quite similar in form and size.

In rice farms near Niu-Kioh-To, Jan., 1934 (S631, S668, S750, and S671); in a well near Chiangpei, Nov. 4, 1933 (S742 and S752); in a rice farm near Lung-Yin-Ch'ang, Jan. 2, 1933 (S489); in a rice farm near Fou-Tu-Kuan, Jan., 1933 (S448); in rice farms, Li-Tze-Pa, Nov. 20, 1933 and Jan., 1934 (S678, S680, S690, S698 and S701); in a shallow ditch near Tseng-Chia-Yen, Dec. 14, 1933 (S722); in a rice farm, Ta-Chi-Kou, Nov. 14, 1934 (S758). Type in C. C. Jao collections and Herb. Univ. Mich., No. S631.

35. *Spirogyra lamellosa*, sp. nov.

(Pl. IX, fig. 99)

Cellulis vegetativis $29-32\mu$ latis, $188-280\mu$ longis; dissepimentis replicatis; chromatophoris singulis, anfractibus 4—6; conjugatione scalari; tubis conjugationis tenuibus et longissimis, a gametangiis feminis ad masculis $32-96\mu$ longis, $10-13\mu$ latis; cellulis fructiferis cylindricis vel zygospora leviter inflatis; zygosporis cylindrico-ellipsoideis vel ellipsoideis, apice acuminatis, $32-42\mu$ latis, $80-102\mu$ longis; membrana sporae triplici; episporio laevi, hyalino, lamellosa et crasso, crassitudine $3-4\mu$; mesosporio laevi, maturitate flavescente; endosporio distincto.

Vegetative cells $29-32\mu$ diameter, $188-280\mu$ long, with replicate end walls; one chromatophore, making 4—6 turns in the cell; conjugation scalariform; conjugation tubes narrow and very long, $32-96\mu$ long from one gametangium to another, $10-13\mu$ diameter; fertile cells cylindrical or slightly enlarged by the zygosporangia; zygosporangia cylindric-ellipsoid or ellipsoid, with pointed ends, $32-42\mu$ diameter, $80-102\mu$ long; spore wall of three layers; episporium smooth, colorless, lamellose and thick, with a thickness from 3 to 4μ ; mesospore smooth, yellow at maturity; endospore distinct.

In size this new species is very close to *Spirogyra semionata* Jao, but differs from it in having the zygosporangia with

pointed ends, in having the epispore very thick and lamellose, and in having the conjugation tubes narrow and very long. It is distinguished from *Spirogyra laxa* Kützing in having much larger zygospores and very thick and lamellose epispore.

In a stony pool near Liu-Chia-Tan, Dec. 27, 1933 (S588); in a rice farm, Ta-Chi-Kou, Dec. 15, 1933 (S735). Type in C. C. Jao collections and Herb. Univ. Mich., No. S588.

36. *Spirogyra tenuissima* (Hassall) Kützing 1849

(Pl. IX, fig. 100)

Vegetative cells 9—13 μ diameter, 161—346 μ long, with replicate end walls; one chromatophore, with irregularly toothed margins, making 3—6.5 turns in the cell; conjugation scalariform and lateral; conjugation tubes formed by both male and female gametangia; fertile cells much inflated toward the middle, extreme diameter 29—39 μ ; zygospores ellipsoid, with more or less pointed ends, (22—) 24—29 μ diameter, 48—74 μ long, mesospore smooth, yellow at maturity.

These local plants have the zygospores of rather smaller diameter and greater length, otherwise they are quite close to the typical form.

In rice farms near Liu-Tien-Tze, Feb., 1932 (S329: S2 and S334); in a rice farm, Ta-Chi-Kou, Dec. 15, 1933 (S753); in rice farms near Lung-Yin-Ch'ang, Dec., 1933 (S132 and S135).

37. *Spirogyra inflata* (Vaucher) Rabenhorst 1868

(Pl. IX, fig. 101)

Vegetative cells slender, 18—23 μ diameter, 115—260 μ long, with replicate end walls; one chromatophore, broad and loose, making 2—7 turns in the cell; conjugation commonly lateral, sometimes scalariform; conjugation tubes formed by both male and female gametangia; fertile cells greatly inflated toward the middle, extreme diameter up to 42 μ ; zygospores ellipsoid, with more or less pointed ends, 27—34 μ long, mesospore smooth, yellow at maturity.

These local plants have the vegetative cells of rather greater diameter, otherwise they are very close to the typical form.

In a rice farm near Shih-Chia-Ch'ang, Jan. 29, 1933 (S436).

38. *Spirogyra cylindrica* Czurda 1932

(Pl. IX, fig. 102)

Vegetative cells $13\text{--}16\mu$ diameter, $140\text{--}350\mu$ long, with replicate end walls; one chromatophore, making 2.5—6 turns in the cell; conjugation lateral or sometimes scalariform; conjugation tubes formed by the male gametangia only; fertile cells mostly cylindrically inflated, $29\text{--}42\mu$ in diameter; zygospores ellipsoid, with pointed ends, (19—) $22\text{--}32\mu$ diameter, (37—) $51\text{--}71\mu$ long; spore wall smooth, yellowish brown at maturity.

These Chinese plants are a little larger than Czurda's specimens. Czurda has named another species *Spirogyra austriaca* (1932); its habits are like those of *S. cylindrica*, and their measurements are not much unlike. *S. cylindrica* has the vegetative cells $13\text{--}15\mu$ diameter; zygospores $23\text{--}30\mu$ diameter and $60\text{--}68\mu$ long. *S. austriaca* has the vegetative cells $14\text{--}16\mu$ diameter; zygospores $26\text{--}32\mu$ diameter and $58\text{--}68\mu$ long. These show the vegetative cells of *S. austriaca* as only averaging 1μ broader, zygospores $2\text{--}3\mu$ broader and $2\text{--}3\mu$ shorter than those of *S. cylindrica*. In many species of *Spirogyra*, the measurements are quite variable, especially those of the zygospores. In the writer's collections he found paired conjugating filaments of this species which sometimes showed one filament 13μ in diameter and the other one up to 16μ , and also the zygospores of an individual filament as differing in diameter and in length. For these reasons, the species *S. austriaca* should be united under the name *S. cylindrica*.

In rice farms near Fou-Tu-Kuan, Jan., 1933 (S451 and S458); in a rice farm near Shih-Chiao-Ch'ang, Jan., 1933 (S745); in a muddy ditch, Li-Tze-Pa, Nov. 11, 1933 (S755); in a rice farm near Hsian-Kuo-Shih, Dec. 27, 1933 (S555); in

a rice farm, Sha-P'in-Pa, Nov. 10, 1934 (S660); in a rice farm, Hsiao-Lung-Kan, Nov. 11, 1934 (S659).

39. *Spirogyra pseudospreeiana*, sp. nov.

(Pl. IX, fig. 103)

Cellulis vegetativis $16-19\mu$ latis, $140-210\mu$ longis, dissepimentis replicatis; chromatophoris singulis, anfractibus $2.5-8$; conjugatione scalari; tubo conjugationis solum ex cellula mascula emisso; cellulis fructiferis uno latere (in quo conjugatio sequitur) inflatis; latitudine usque ad 39μ ; zygosporis ellipsoideis, $22-35\mu$ latis, $45-64\mu$ longis, membrana laevi, maturitate fusciscente.

Vegetative cells $16-19\mu$ diameter, $140-210\mu$ long, with replicate end walls; one chromatophore, making $2.5-8$ turns in the cell; conjugation scalariform; conjugation tubes evidently formed by the male gametangia only; fertile cells inflated on the conjugating side and toward the middle, up to 39μ in diameter; zygosporis ellipsoid, $27-35\mu$ diameter, $45-64\mu$ long, spore wall smooth, yellowish brown at maturity.

This new species is separated from *Spirogyra Spreeiana* Rabenhost chiefly by its smaller vegetative cells and fertile cells inflated on the conjugating side only.

In rice farms near Lung-Yen-Ch'ang, Dec., 1933 (S103 and S150). Type in C. C. Jao collections and Herb. Univ. Mich., No. S103.

40. *Spirogyra hopeiensis*, sp. nov.

(Pl. IX, fig. 104)

Cellulis vegetativis $26-29\mu$ latis, $154-400\mu$ longis, dissepimentis replicatis; chromatophoris singulis, anfractibus $2-6$; conjugatione scalari; tubo conjugationis solum ex cellula mascula emisso; cellulis fructiferis uno latere (in quo conjugatio sequitur) inflatis, latitudine usque ad 55μ ; zygosporis ellipsoideis, apice acuminatis, $32-48\mu$ latis, $61-96\mu$ longis, membrana laevi, maturitate flavescenti.

Vegetative cells $26\text{--}29\mu$ diameter, $154\text{--}400\mu$ long, with replicate end walls; one chromatophore, making 2—6 turns in the cell; conjugation scalariform; conjugation tubes formed by the male gametangia only; fertile cells inflated on the conjugating side, with a diameter up to 55μ ; zygospores ellipsoid, with pointed ends, $32\text{--}48\mu$ diameter, $61\text{--}96\mu$ long, spore wall smooth, yellow at maturity.

This species in size is near to *Spirogyra Farlowii* Transeau, but is distinguished from it chiefly in having much longer vegetative cells, in having the fertile cells inflated on the conjugating side, and in having the conjugation tubes formed from the male gametangia only.

This species was first discovered in a collection (H242) from Peiping, Hopei, North China, June, 1928, and found again from a rice farm near Hsian-Kuo-Shih, Dec. 27, 1933 (S558). Type in C. C. Jao collections No. H242.

41. *Spirogyra Chuniae* Jao 1935

(Pl. X, fig. 105)

Vegetative cells $28\text{--}39\mu$ diameter, $67\text{--}130\mu$ long, with replicate end walls; one chromatophore, sometimes two, with undulate margins and containing large pyrenoids, making 2—2.5 turns in the cell; fertile cells inflated, reaching a diameter of 80μ ; conjugation scalariform; conjugation tubes very short, sometimes formed only by the male gametangia; zygospores ellipsoid, with pointed ends, $35\text{--}43\mu$ diameter, (70—) $73\text{--}119\mu$ long, spore wall smooth, yellow at maturity.

In some respects this species resembles *Spirogyra Grevilleana* (Hassall) Kützing, but differs in the form of the zygospores and in greater dimensions of all cells, except the vegetative cells which are shorter.

In a rice farm near Chungking, Jan., 1933 (S461).

42. *Spirogyra Hassallii* (Jenner) Petit 1880

(Pl. X, fig. 106)

Vegetative cells $32\text{--}35\mu$ diameter, $115\text{--}350\mu$ long, with replicate end walls; two chromatophores, broad and loose,

making 1.5—3.5 turns in the cell; fertile cells enlarged by the zygospores, up to 48μ in diameter; zygospores ellipsoid to cylindric-ellipsoid, with more or less rounded ends, $38\text{--}45\mu$ diameter, $110\text{--}150\mu$ long, spore wall smooth, yellow at maturity.

The writer has only found a few fruiting filaments in his material. According to the available data, this plant seems to be *S. Hassallii* (Jenner) Petit.

In a rice farm near Chiangpei, Jan., 1933 (S408: Sla).

43. *Spirogyra Transeauiana* Jao 1935

(Pl. X, fig. 107)

Vegetative cells $42\text{--}58$ ($\text{--}61$) μ diameter, $160\text{--}304\mu$ long, with replicate end walls; 2—3 chromatophores, making 2—5 turns in the cell; conjugation scalariform; fertile cells cylindrical or slightly enlarged by the zygospores on the conjugating side; zygospores ellipsoid, with rounded ends, $41\text{--}58\mu$ diameter, $96\text{--}183\mu$ long, spore wall smooth, yellow at maturity.

This species shows some characteristics of *Spirogyra proavita* Langer, *S. aequalis* Harvey and *S. Hassallii* (Jenner) Petit. It differs from them chiefly in having all cells larger and in the scalariform conjugation.

In a rice farm near Chungking, Jan., 1933 (S461: S1 and S2).

44. *Spirogyra foveolata* (Skuja) Czurda 1932

(Pl. X, figs. 109, 110)

Vegetative cells $13\text{--}16\mu$ diameter, $105\text{--}245\mu$ long, with replicate end walls; one chromatophore, making 3—6 turns in the cell; conjugation scalariform and lateral; conjugation tubes formed by the male gametangia only; fertile cells greatly inflated toward the middle, up to $35\text{--}55\mu$ in diameter; zygospores ellipsoid, with more or less pointed ends, $26\text{--}34\mu$ diameter, $57\text{--}67\mu$ long, mesospore reticulate, yellow at maturity.

In rice farms near Lung-Yin-Ch'ang, Dec., 1934 (S116) and near Hsian-Kuo-Shih, Nov. 27, 1933 (S555).

45. *Spirogyra laxistrata*, sp. nov.

(Pl. X, fig. 111)

Cellulis vegetativis $18-20\mu$ latis, $112-147\mu$ longis, dissepimentis replicatis; chromatophoris singulis, anfractibus $2.5-4$; conjugatione scalari; tubo conjugationis omnino ex cellula mascula emisso; cellulis fructiferis cylindriciter inflatis; zygosporis abbreviatiter obovoideis, $35-38\mu$ latis, $45-48\mu$ longis; membrana quadruplici, mesosporio exteriori laevi, crasso et flavescenti, mesosporio interiore crasse et angulate areolato, maturitate fusciscenti.

Vegetative cells $18-20\mu$ diameter, $112-148\mu$ long, with plane end walls; one chromatophore, making $2.5-4$ turns in the cell; conjugation scalariform, tubes formed by the male gametangia only; fertile cells cylindrically inflated; zygosporis shortly obovoid, $35-38\mu$ diameter, $45-48\mu$ long; spore wall of four layers, outer mesospore smooth, thick and yellow, inner mesospore coarsely and angularly areolate and yellowish brown at maturity.

This species is quite isolated in this genus, as it has the conjugation tubes formed by the male gametangia only, the zygosporis shortly obovoid, and the spore wall four-layered, of which the outer mesospore is smooth and thick and inner mesospore coarsely and angularly areolate. With these characteristics, it is most clearly separated from the other species which have the end walls replicate, one chromatophore, and the fertile cells cylindrically inflated.

In a pond near Hsian-Kuo-Shih, Dec. 27, 1933. Type in C. C. Jao collections and Herb. Univ. Mich., No. S578: 03.

46. *Spirogyra dentireticulata*, sp. nov.

(Pl. X, figs. 114, 115)

Cellulis vegetativis $18-26\mu$ latis, $118-250\mu$ longis; dissepimentis replicatis; chromatophoris singulis; anfractibus $2-7$; conjugatione scalari; cellulis fructiferis zygospora inflatis; zygosporis ellipsoideis, apice plus minusve rotundatis, $29-41\mu$

latis, 42—80 μ longis, mesosporio reticulato, reticulationibus intersectionibus dentatis, maturitate flavescenti.

Vegetative cells 19—26 μ diameter, 118—250 μ long, with replicate end walls; one chromatophore, making 2—7 turns in the cell; fertile cells enlarged by the zygospores; zygospores ellipsoid, with more or less rounded ends, 29—41 μ diameter, 42—80 μ long, mesospore reticulate, reticulations spinulose-dentate at the intersections, yellow at maturity.

This species is characterized by the enlarged fertile cells and the spinulose-reticulate mesospore, which distinguish it from other species which have replicate end walls, one chromatophore, the fertile cells not inflated and the zygospores ellipsoid in form.

In a rice farm near Chiangpei, Jan., 1933 (S405: S2); in rice farms near Lung-Yin-Ch'ang, Dec., 1933 (S151 and S152). Type in C. C. Jao collections and Herb. Univ. Mich., No. S405: S2.

47. *Spirogyra microgranulata*, sp. nov.

(Pl. X, figs. 112, 113)

Cellulis vegetativis 16—19 μ latis, 154—420 μ longis, dispimentis replicatis; chromatophoris singulis, anfractibus 4.5—8; conjugatione scalaris; cellulis fructiferis zygospora inflatis; zygosporis obovoideis, 24—36 μ latis, 51—77 μ longis; membrana quadruplici, episporio exteriori hyalino et tenui, episporio interiori tenui, hyalino et leviter rugoso, mesosporio minute granulato vel verrucoso et maturitate fusciscenti, endosporio tenui.

Vegetative cells 16—19 μ diameter, 154—420 μ long, with replicate end walls; one chromatophore, making 4.5—8 turns in the cell; conjugation scalariform; fertile cells enlarged by the zygospores; zygospores obovoid, 24—36 μ diameter, 51—77 μ long, spore wall of four layers, outer episporium thin and colorless, inner episporium colorless, thin and slightly wrinkled, mesospore finely granulate to verrucose and yellowish brown at maturity, endospore thin.

In size this species is very close to *Spirogyra arta* Jao. It differs, however, from *S. arta* in having larger zygospores, the episporium of two layers and the mesospore granulate to verrucose. It also should be compared with *Spirogyra Petitiana* Transeau; however, this new species has smaller dimensions, its mesospore is not smooth and inner episporium not scrobiculate.

In a rice farm, Ta-Chi-Kou, Dec. 14, 1933. Type in C. C. Jao collections and Herb. Univ. Mich., No. S735: S1.

48. *Spirogyra granulata*

(Pl. XI, figs. 116, 117)

Cellulis vegetativis $32-35\mu$ latis, $147-280\mu$ longis, dissepimentis replicatis; chromatophoris 2, anfractibus $2.5-6$; conjugatione laterali; cellulis fructiferis zygospora inflatis; zygosporis obovoideis vel cylindrico-obovoideis, $45-55\mu$ latis, $93-131\mu$ longis, membrana quadruplici, episporio hyalino, mesosporio exteriori fuscescenti, crasse et irregulariter rugoso, mesosporio interiori fuscescenti, minute granulato et debiliter rugoso, endosporio tenui et distincto.

Vegetative cells $32-35\mu$ diameter, $147-280\mu$ long, end walls replicate; two chromatophores, making $2.5-6$ turns in the cell; conjugation lateral; fertile cells enlarged by the zygospores; zygospores obovoid to cylindric-obovoid, $45-55\mu$ diameter, $93-131\mu$ long, spore wall of four layers, episporium colorless, outer mesospore yellowish brown, coarsely and irregularly wrinkled, inner mesospore yellowish brown, finely granulate and a little wrinkled, endospore thin and distinct.

This species is near *Spirogyra reticulata* Nordstedt and *S. regularis* Cedercreutz. It is characterized by longer zygospores having the wall of four layers, which differentiate it from them. The inner mesospore is not very sharply granulate on some portions, but the ornamentation is somewhat irregular, soft, and at times a little vague.

In a rice farm near Lung-Yin-Ch'ang, Dec., 1933 (S103). Type in C. C. Jao collections No. S103.

49. *Spirogyra venusta*, sp. nov.

(Pl. X, fig. 118, 119)

Cellulis vegetativis $25-27\mu$ latis, $175-350\mu$ longis, dissepimentis replicatis; chromatophoris singulis, anfractibus 3—6; conjugatione scalari; cellulis sterilis inflatis ad uterque apicis; cellulis fructiferis cylindricis vel zygospora leviter inflatis; zygosporis cylindraceo-obovoideis, $26-32\mu$ latis, $67-84\mu$ longis, membrana quadruplici, episporio interiore valide scrobiculato et hyalino, mesosporio laevi, maturitate flavescenti.

Vegetative cells $25-27\mu$ diameter, $175-350\mu$ long, with replicate end walls; one chromatophore, making 3—6 turns in the cell; conjugation scalariform; sterile cells inflated at both ends; fertile cells cylindrical or slightly enlarged by the zygosporis; zygosporis cylindric-ellipsoid, $26-32\mu$ diameter, $67-84\mu$ long; spore wall of four layers, inner episporis colorless and strongly scrobiculate, mesosporis smooth and yellow at maturity.

This species is quite isolated in this genus, as it has the sterile cells inflated at both ends, the zygosporis being cylindric-obovoid in form and with the inner episporis strongly scrobiculate, the end walls replicate and one chromatophore. By these first two characteristics it is most clearly separated from other species which have replicate end walls, one chromatophore, and cylindrical or enlarged fertile cells.

In a pond near Liu-Chia-Tan, Dec. 27, 1933. Type in C. C. Jao collections No. S588: 1.

50. *Spirogyra Cleveana* Transeau 1934

(Pl. XI, fig. 120)

Vegetative cells $32-40\mu$ diameter, $126-350\mu$ long, with replicate end walls; one chromatophore, sometimes two, making 2—3 turns in the cell; conjugation scalariform; fertile cells cylindrical or enlarged by the zygosporis; sterile cells sometimes greatly inflated, up to 83μ in diameter; zygosporis obovoid to cylindric-obovoid, $38-51\mu$ diameter, $70-125\mu$ long; spore wall of four layers; inner episporis very deeply scrobi-

culate, the pits separated laterally below by thick partitions and at the angles by thick intersections of these, but laterally between the pits the membranes become very thin above, and the pits may intercommunicate below the outer epispore membrane; mesospore smooth and yellow at maturity.

These local plants are quite similar to Transeau's type, excepting that the diameter of the zygospores is a little larger and the sterile cells sometimes are greatly inflated.

In rice farms near Hsian-Kuo-Shih and Niu-Chia-Tan, Nov. 27, 1933 (S555, S553 and S580); in a rice farm, Li-Tze-Pa, Nov. 20, 1933 (S690); in a rice farm, Ta-Chi-Kou, Dec. 14, 1933 (S730).

51. *Spirogyra quinquilaminata*, sp. nov.

(Pl. XI, figs. 121, 122)

Cellulis vegetativis $41\text{--}45\mu$ latis, $154\text{--}280\mu$ longis, dissepimentis replicatis; chromatophoris 2, anfractibus 2—4; generationibus zygosporis vel aplanosporis ortis; conjugatione scalari; tubo conjugationis ex utraque cellula mascula et femina emisso; cellulis fructiferis zygospora inflatis vel cylindricis; cellulis sterilis interdum usque ad latitudinem 70μ tumidatis; zygosporis ellipsoideis, apice rotundatis, $51\text{--}55\mu$ latis, $83\text{--}144\mu$ longis; aplanosporis globosis, subglobosis vel subellipsoideis, $41\text{--}48\mu$ latis, $41\text{--}67\mu$ longis; membrana quinquiplici, episporio exteriori hyalino et tenui, episporio interiori hyalino, plus minusve distincte lamelloso et crassitudine usque ad 3.5μ , mesosporio exteriori tenui, flavescenti et leviter rugoso, mesosporio interiori fusciscenti et reticulato, reticulis crassis et irregulariter crenulatis vel dentatis, endosporio tenui et distincto.

Vegetative cells $41\text{--}45\mu$ diameter, $154\text{--}280\mu$ long, with replicate end walls; two chromatophores, making 2—4 turns in the cell; reproduction by both zygospores and aplanospores; conjugation scalariform; conjugation tubes formed by both male and female cells; fertile cells enlarged by the zygospores or cylindrical; sterile cells sometimes swollen up to 70μ in diameter; zygospores ellipsoid, with rounded ends, $51\text{--}55\mu$ dia-

meter 83—144 μ long; aplanospores globose, subglobose or subellipsoid, 41—48 μ diameter, 41—67 μ long; spore wall of five layers, outer epispore colorless and thin, inner epispore colorless, more or less distinctly lamellose, and with a thickness up to 3.5 μ , outer mesospore thin, yellow and a little wrinkled, inner mesospore yellowish brown and reticulate, reticulations thick and irregularly crenulate to dentate, endospore thin and distinct.

This new species is nearest to *Spirogyra crassivallicularis* Jao, an American plant found by the writer from Harper Pond, woods Hole, Massachusetts, U. S. A., 1933. It is characterized by smaller dimensions of the vegetative cells, two chromatophores, sterile cells sometimes swollen, and the colorless epispore thick and distinctly separating into two layers. These characteristics are enough to distinguish it from *S. crassivallicularis* Jao.

In a rice farm near Chiangpei, Nov. 11, 1933. Filaments scattered among those of *Spirogyra semiornata* Jao. Type in C. C. Jao collections No. S750.

VI. *Sirogonium* Kützing 1843

Filaments simple; cells 2—6 diameters long, end walls plane; 2—9 chromatophores, parietal, straight or slightly spiral, containing a single row of pyrenoids; reproduction by zygospores, conjugation direct between short geniculate gametangia of different filaments; prior to conjugation certain of the vegetative cells divide into two sister cells, one of which becomes a gametangium and the other remains sterile¹; spore wall of three layers; mesospore smooth or variously marked, yellow to brown at maturity.

One species and one variety were found in the writer's collections. They are often found in very shallow water or on very damp soil associating with *Vauchera*, mostly pure.

1. This character also found in few species of *Spirogyra*, such as *S. Collinsii* (Lewis) Printz and *S. Collinsii* (Lewis) Printz var. *ampla* Jao.

1. *Sirogonium sticticum* (Engl. Bot.) Kützing 1843

(Pl. XII, fig. 123)

Forming yellow-green masses; vegetative cells $38\text{--}45\mu$ diameter, $96\text{--}208\mu$ long; 3—4 chromatophores, rarely 5, narrow, parallel and longitudinal or slightly spiral; fertile cells shortened and somewhat tumid, up to 64μ in diameter, geniculate; male gametangia usually shorter than the female, both solitary on the fruiting filament; zygospores ellipsoid with rounded ends, sometimes kidney-shaped, $48\text{--}58\mu$ diameter, $92\text{--}118\mu$ long; mesospore smooth, yellow to yellowish brown at maturity.

In rice farms, Lung-Yen-Ch'ang, Dec., 1933 (S120, S135 and S156); Liu-Kioh-To, Feb., 1933 (S342 and S348); Ta-Chi-Kou, Dec. 15, 1933 (S738); Tseng-Chia-Yen, Dec. 14, 1933 (S727).

2. *Sirogonium sticticum* (Engl. Bot.) Kützing

var. *megasporum*, var. nov.

(Pl. XII, figs. 124—127)

Cellulis vegetativis $48\text{--}385\mu$ latis, $90\text{--}385\mu$ longis; chromatophoris 3—4, interdum 2, directis vel anfractibus 0.5; cellulis conjugationis geniculatis et abbreviatis; cellulis fructiferis inflatis latitudine usque ad 100μ ; zygosporis ellipsoidis vel reniformibus, apice rotundatis, $70\text{--}85\mu$ latis, $100\text{--}128\mu$ longis; membrana laevi, maturitate fusciscenti.

Vegetative cells $48\text{--}55\mu$ diameter, $90\text{--}385\mu$ long, 3—4 chromatophores, sometimes 2, straight or making 0.5 turns in the cell; conjugating cells geniculate and shortened; fertile cells inflated up to 100μ in diameter; zygospores ellipsoid to kidney-shaped, with rounded ends, $70\text{--}85\mu$ diameter, $100\text{--}122\mu$ long; spore wall smooth, yellowish brown at maturity.

This variety has greater dimensions of zygospores than the typical species. In three of the writer's collections this variety, nearly pure, is represented. The measurements of

zygospores were not less than 70μ in diameter. The writer also has had in hand several pure collections of typical *Sirogonium sticticum* (Engl. Bot.) Kützing, which show the measurements of all cells as being constantly smaller than in this new variety, especially their zygospores, as described in this paper. *Sirogonium floridanum* (Transeau) Smith is characterized by greater dimensions than *S. sticticum*, vegetative cells $56\text{--}66\mu$ diameter, $120\text{--}335\mu$ long; zygospores $75\text{--}105\mu$ diameter, $95\text{--}135\mu$ long, and chromatophores 4—6 in number. This new variety is smaller and has fewer chromatophores.

In rice farms Li-Tze-Pa, Jan., 1934 (S678 and S684); in a stony pool, Tseng-Chia-Yen, Dec. 14, 1933 (S706). Type in C. C. Jao collections and Herb. Univ. Mich., No. S678.

BIBLIOGRAPHY

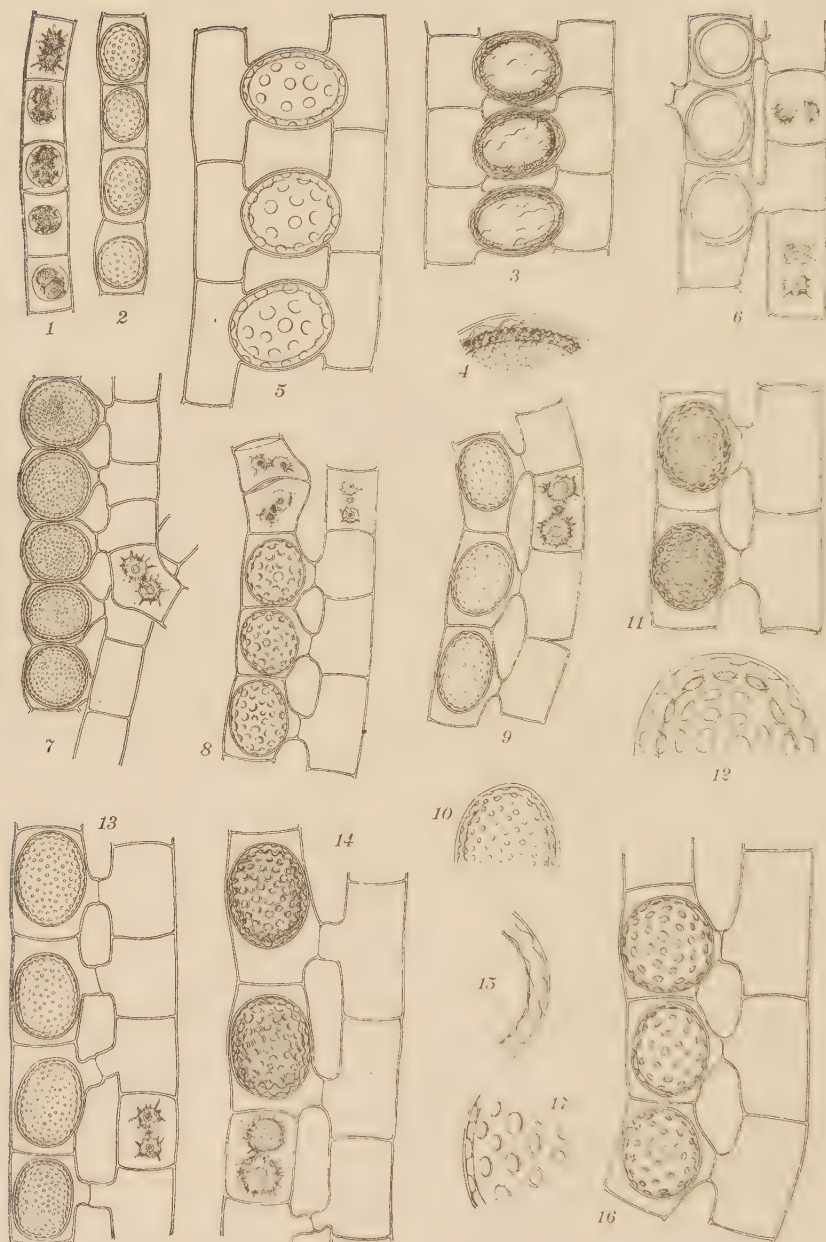
- Agardh, C. A. 1824. *Systema algarum*. Lundae.
- Borge, O. 1903. Die Algen der ersten Regnellschen Expedition. III. Zygnemaceem und Mesocarpaceen. *Ark. för Bot.* 1: 277.
- Collins, F. S. 1909, 1912 & 1918. *Green Algae of North America*. Tuft College Studies Vol. II, No. 3. 1909; 1st. Supplement, *idem* Vol. III, No. 2, 1921; 2nd. Supplement, *idem* Vol. IV, No. 7. 1918.
- Czurda, V. 1930. Experimentelle Untersuchungen über die Sexualitätsverhältnisse der Zygnemalen. *Beih. z. bot. Centralbl.* 47: 15.
- 1932. *Zygnemales*. Heft 9. Die Süßwasser-Flora Mitteleuropas. Jena.
- De Toni, G. B. 1889. *Sylloge algarum omnium hucusque cognitarum*. I. Chlorophyceae. Padua.
- Harvey, F. L. 1892. The Freshwater Algae of Maine. III. *Bull. Torrey Bot. Club* 19: 118.
- Hassall, A. H. 1842. Observation on the Genus *Zygnema*, *Tyndaridea* and *Mougeotia* with Description of New Species. *Ann. and Mag. of Nat. Hist.* 10: 34.
- 1843. Description of British Freshwater Confervae, Mostly New, With Observation on Some of the Genera. *Ann. and Mag. of Nat. Hist.* 11: 428.
- 1843. Observation on the Genus *Mougeotia*, on to New Genera of Freshwater Algae and on *Tyndaridea*, with Description of Species. *Ann. and Mag. of Nat. Hist.* 12: 180.

- Iyengar, M. O. P. 1932. Studies on Indian Zygnemales. *Rev. Alg.* 6: 263.
- Jao, C. C. 1935. New Zygnemataceae from Woods Hole. *Trans. Amer. Micros. Soc.* 54: 1.
- 1935. New Zygnemataceae Collected in China. *Amer. Jour. Bot.* (in press).
- Kützing, F. T. 1843. *Phycologia generalis*. Leipzig.
- 1849. *Species algarum*. Leipzig.
- 1849—1869. *Tabulae phycologicae*. Nordhausen.
- Li, L. C. 1933. New Species and Varieties of Freshwater Algae from China. *Ohio Jour. Sci.* 30: 151.
- Petit, P. 1880. *Spirogyra des environ de Paris*. Paris.
- Rabenhorst, L. 1868. *Flora Europae algarum aquae dulcis et submarinae*. III. Leipzig.
- Schmidle, W. 1897. Zur Entwicklung einer Zygnema und Calothrix. *Flora* 84: 167.
- Skuja, H. 1928. Vorarbeiten zu einer Algenflora von Lettland IV. *Acta Horti Bot. Univ. Latviensis*. III: 103.
- 1929. Süßwasseralgen von den westestnischen Inseln Saaremaa und Hiiumaa. *Acta Horti Bot. Univ. Latviensis* 4: 1.
- Smith, G. M. 1933. *The Freshwater Algae of the United States*. McGraw-Hill Book Co., New York.
- Taylor, W. R. 1928. The Alpine Algae Vegetation of the Mountains of British Columbia. *Proc. Acad. Nat. Sci. Philadelphia*. 80: 45.
- 1935. Alpine Algae from the Santa Marta Mountains, Colombia. *Amer. Jour. Bot.* (in press).
- Tiffany, L. H. 1924. Some New Forms of *Spirogyra* and *Oedogonium*. *Ohio Jour. Sci.* 24: 180.
- Transeau, E. W. 1914. New Species of Green Algae. *Amer. Jour. Bot.* 1: 289.
- 1916. Notes on the Zygnemales. *Ohio Jour. Sci.* 16: 17.
- 1925. The Genus *Debarya*. *Ohio Jour. Sci.* 25: 193.
- 1926. The genus *Mougeotia*. *Ohio Jour. Sci.* 26: 311.
- 1933. The Genus *Zygogonium*. *Ohio Jour. Sci.* 33: 156.
- 1934. The Genera of the Zygnemataceae. *Trans. Amer. Micros. Soc.* 53: 201.
- 1934. Preliminary Key to the Species of Zygnematales. Mimeographed manuscript.

- Transeau, E. M., L. H. Tiffany, C. E. Taft & L. C. Li 1934. New Species of Zygnemataceae. Trans. Amer. Micros. Soc. 53: 208.
- West, G. S. 1909. The Algae of the Yan Yean Reservoir, Victoria: a Biological and Ecological Study. Jour. Linn. Soc. Bot. 39: 1.
- Algae. I. University Press, Cambridge.
- West, W. & G. S. West. 1902. A Contribution to the Freshwater Algae of Ceylon. Trans. Linn. Soc. London 6: 123.
- 1907. Freshwater Algae from Burma Including a Few From Bengal and Madrras. Ann. Roy. Bot. Garden Calcutta. 6: 175.
- West, G. S. & F. E. Fritsch. 1927. British Freshwater Algae. University Press, Cambridge.
- Wittrock, W. B. 1867. Algologiska studier. I—II. Upsala.
- 1871. Beitrag zur kenntnis der Zygnemaceen und Mesocarpaceen. Hedwigia 6: 88.
- Wolle, R. F. 1887. Freshwater Algae of the United States. I and II. Bethlehem.

PLATES

Plate I



EXPLANATION OF PLATES

PLATE I

General Views $\times 302$; Separate Spore Details $\times 630$.

Figs. 1, 2. *Zygnema spontaneum* Nordstedt. Figure 1, part of the young fruiting filament showing the formation of aplanospores; Figure 2, part of the mature filament, with mature aplanospores.

Figs. 3, 4. *Zygnema verrucosum* Jao, sp. nov.

Fig. 5. *Zygnema sinense* Jao, sp. nov.

Fig. 6. *Zygnema insigne* (Hassall) Kützing.

Fig. 7. *Zygnema calosporum* Jao, sp. nov.

Fig. 8. *Zygnema extenuum* Jao, sp. nov. Two cells of the left filament showing lateral conjugation in an early stage.

Figs. 9, 10. *Zygnema tenue* Kützing.

Figs. 11, 12. *Zygnema carinthiacum* Beck.

Fig. 13. *Zygnema subcruciatum* Transeau.

Figs. 14, 15. *Zygnema fanicum* Li. Figure 15, spore wall in section.

Figs. 16, 17. *Zygnema stellinum* (Vaucher) Agardh.

Plate II

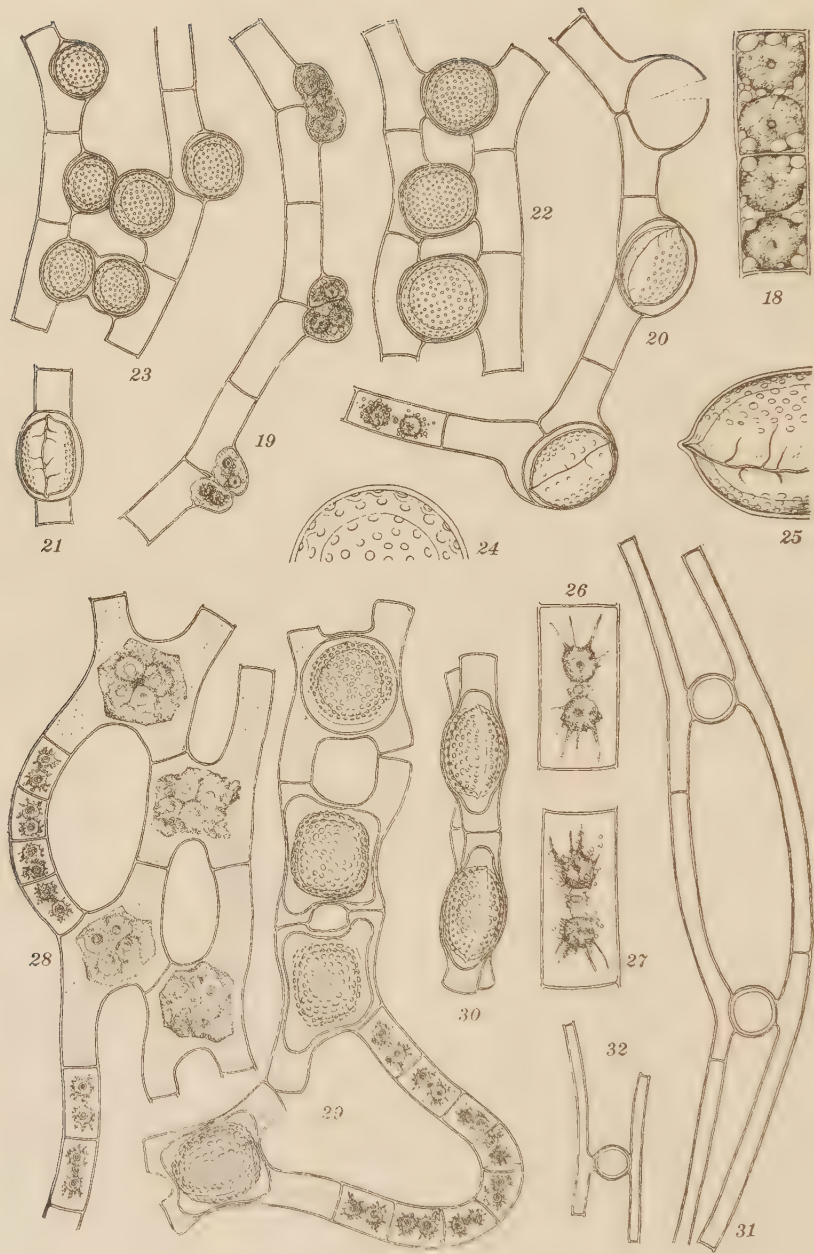


PLATE II

General Views $\times 302$; Vegetative Cells $\times 605$;

Separate Spore Details $\times 630$.

Figs. 18—25. *Zygogonium sinense* Jao, sp. nov. Figure 18, two vegetative cells, containing two irregularly spherical chromatophores and numerous granules in each cell; Figure 19, part of the young fruiting filament in lateral conjugation, showing the formation of zygospores and sporangial walls in different stages; Figure 20, part of a laterally conjugating filament, showing two mature zygospores and one empty, equatorially dehiscent zygosporangium; Figure 21, zygosporangium containing a mature zygospore seen from lateral view, Figure 22, scalariform conjugating filaments with three mature zygospores in polar view; Figure 23, incompletely conjugating filaments, showing the parthenospores; Figures 24 and 25, parts of the zygospores in both polar and lateral views, showing the distribution of markings.

Figs. 26—30. *Zygnemopsis quafrata* Jao, sp. nov. Figure 26, vegetative cell; Figure 27, vegetative cell of fruiting filament, with numerous granules beside the chromatophores; Figure 28, young conjugating filament, showing the formation of zygospores and elongation of gametangia which is filled up by pectic-cellulose colloid; Figure 29, part of the mature fruiting filaments, with four mature zygospores filling the broad conjugation tubes and extending into the gametangia; Figure 30, two zygospores in the gametangia seen from lateral view.

Figs. 31, 32. *Mougeotia parvula* Hassall. Figure 31, smaller form (type II); Figure 32, larger form (type I).

Plate III

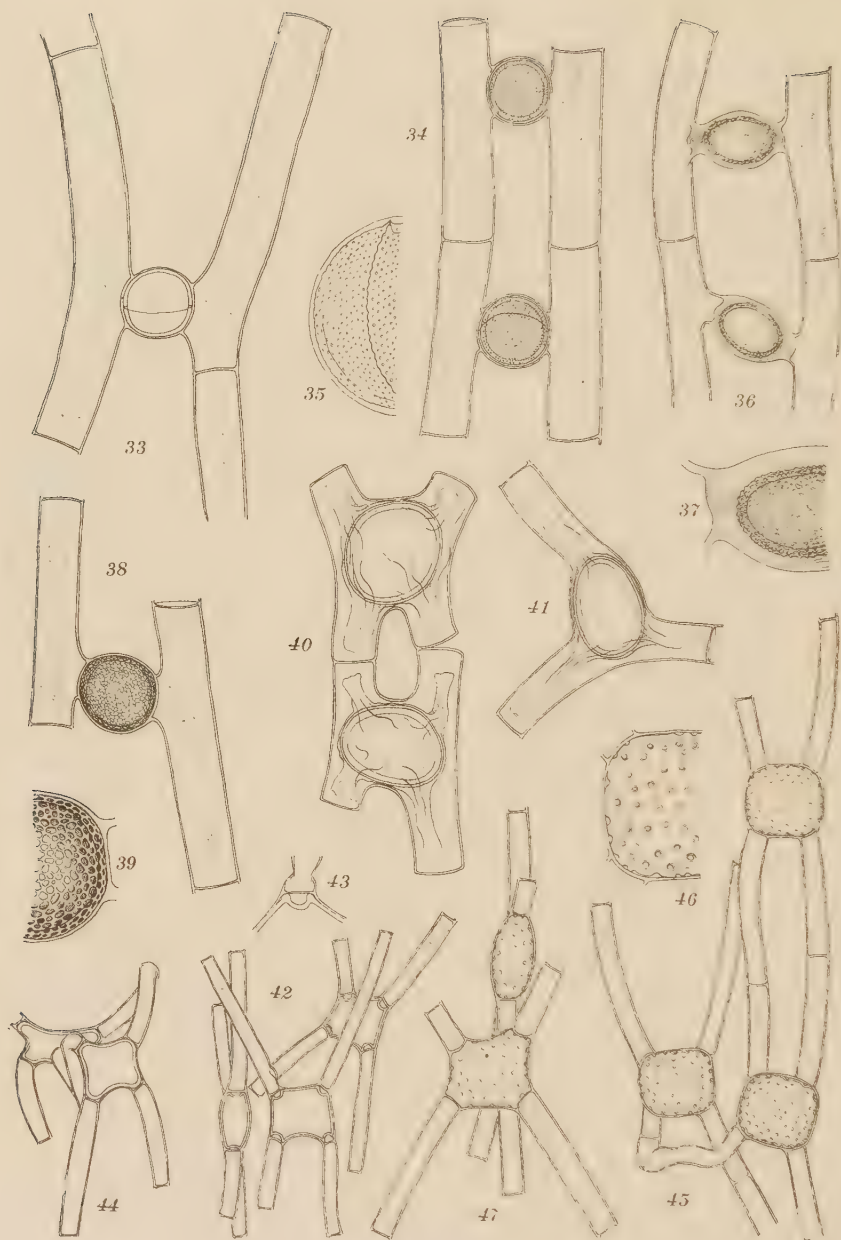


PLATE III

General Views $\times 302$; Separate Spore Details $\times 630$.

Fig. 33. *Mougeotia scalaris* Hassall.

Figs. 34, 35. *Mougeotia ornata* Jao, sp. nov. Figure 35, part of the zygospore, showing the finely undulate ridge and suture on the punctate mesospore.

Figs. 36, 37. *Mougeotia lamellosa* Jao.

Figs. 38, 39. *Mougeotia globulispora* Jao.

Figs. 40, 41. *Mougeotia sphaerocarpa* Wolls. Figure 41, an abnormal conjugation, one of the gametangia (upper) conjugated from its end.

Figs. 42, 43. *Mougeotia viridis* (Kützing) Wittrock. Figure 42, showing the mature conjugating cells in both face (right two) and lateral (left one) views, Figure 43, an angle of the zygospore in face view.

Figs. 45, 46. *Mougeotia rotundangulata* Jao, sp. nov.

Fig. 47. *Mougeotia quadrangulata* Hassall. One zygospore in face view (lower) and one in lateral view (upper).

Plate IV

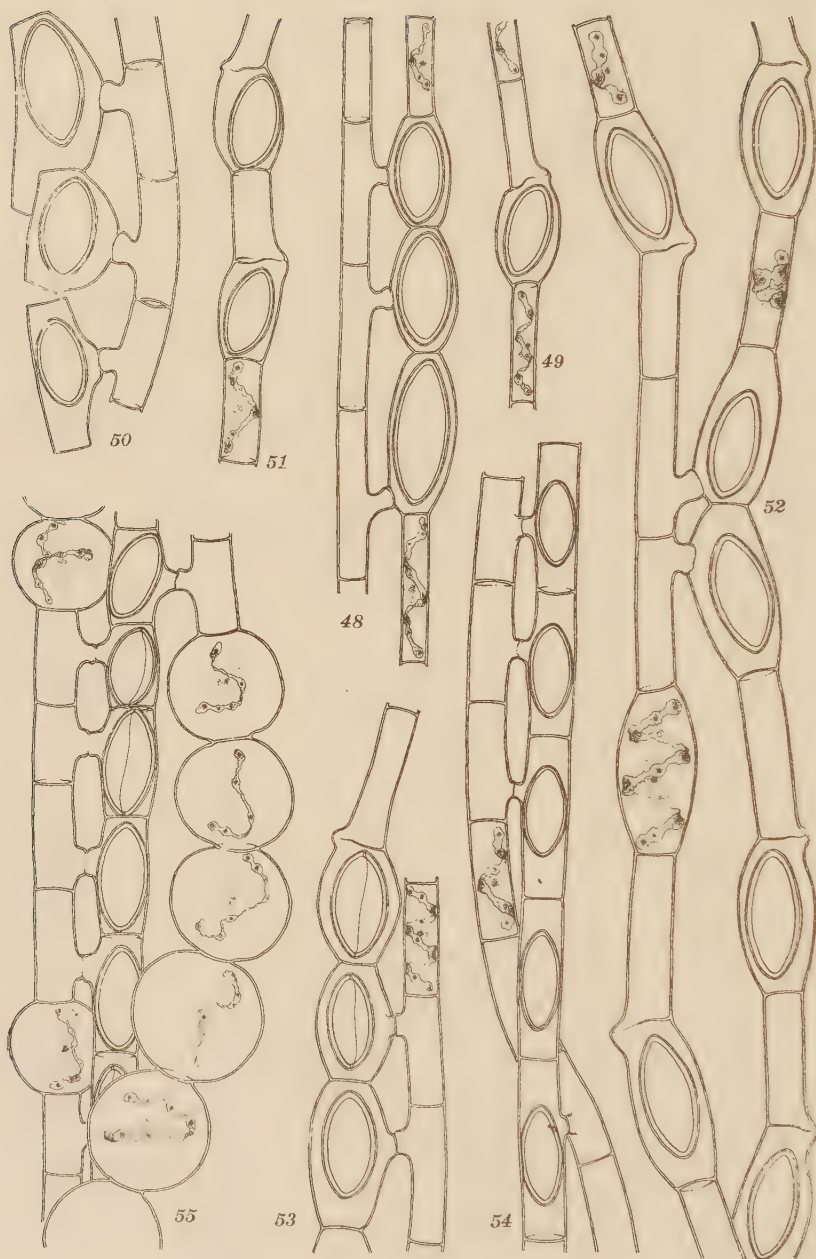


PLATE IV

All Figures $\times 302$

Figs. 48, 49. *Spirogyra Liana* Transeau.

Figs. 50, 51. *Spirogyra gibberosa* Jao, sp. nov.

Fig. 52. *Spirogyra Chenii* Jao, sp. nov.

Fig. 53. *Spirogyra fennica* Cedercreutz.

Fig. 54. *Spirogyra communis* (Hassall) Kützing.

Fig. 55. *Spirogyra bullata* Jao, sp. nov.

Plate V

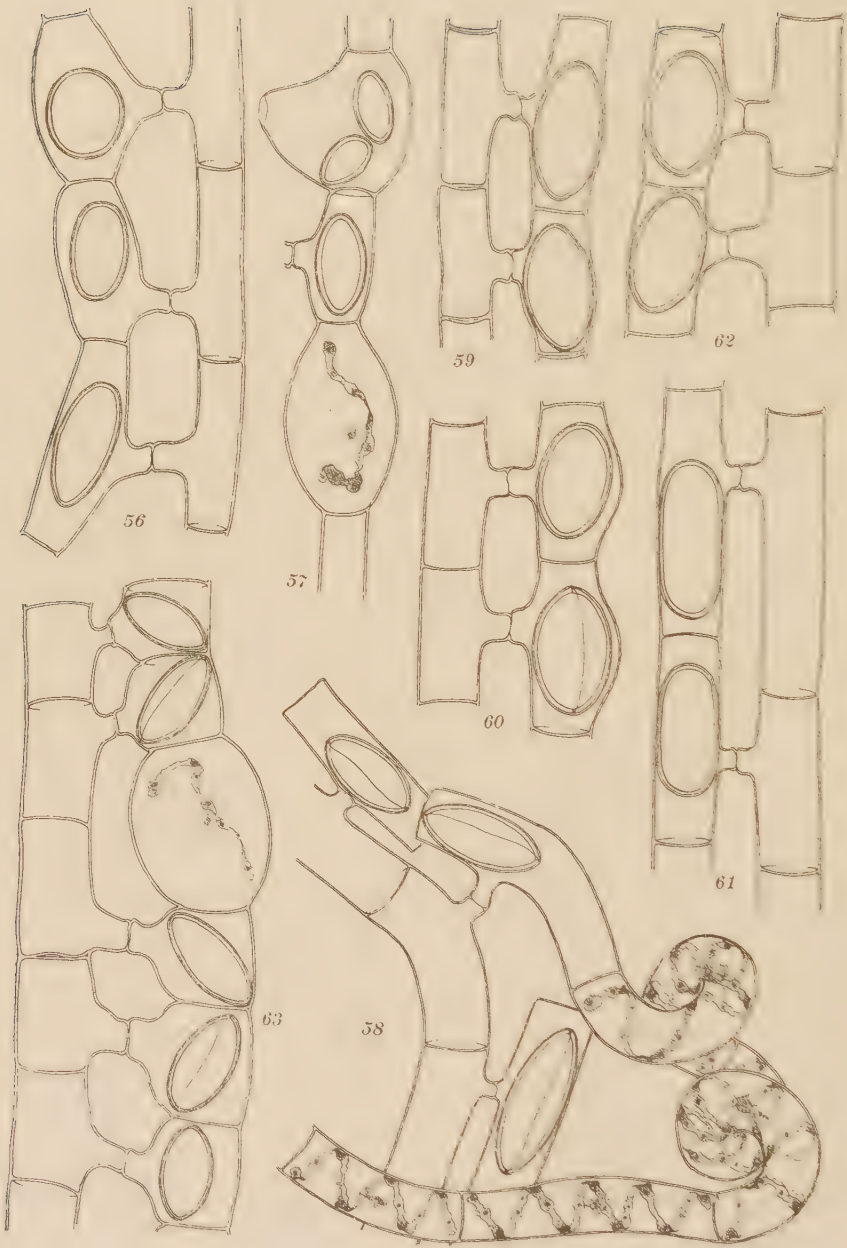


PLATE V

All Figures $\times 302$

- Figs. 56, 57. *Spirogyra polymorpha* Kirchner f.
Fig. 58. *Spirogyra intorta* Jao.
Fig. 59. *Spirogyra Juergensii* Kützing.
Fig. 60. *Spirogyra Borgeana* Transeau.
Fig. 61. *Spirogyra longata* (Vaucher) Kützing.
Fig. 62. *Spirogyra singularis* Nordstedt.
Fig. 63. *Spirogyra varians* (Hassall) Kützing.

Plate VI

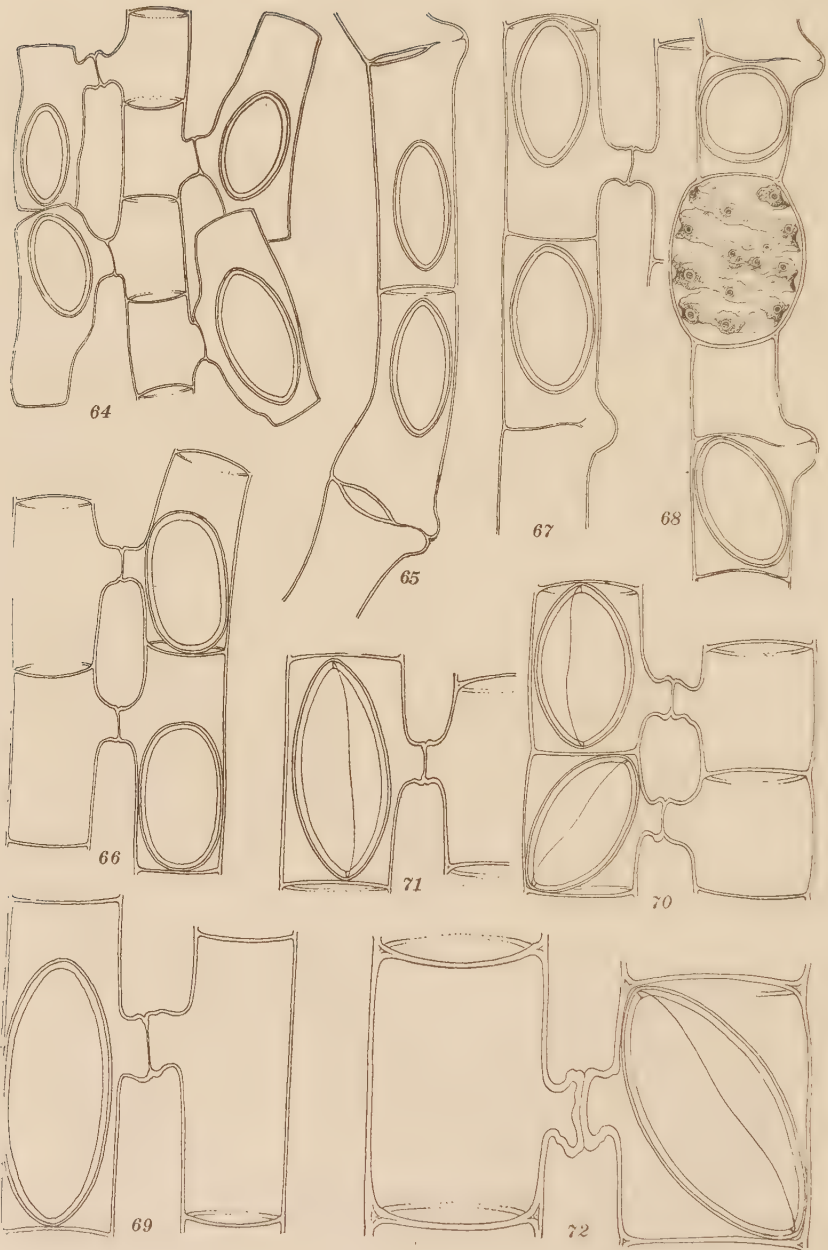


PLATE VI

Figures 64—68 $\times$ 302; Figures 69—72 $\times$ 202

- Fig. 64. *Spirogyra fragilis* Jao, sp. nov.
Fig. 65. *Spirogyra microspora* Jao, sp. nov.
Fig. 66. *Spirogyra decimina* (Müller) Kützing.
Figs. 67, 68. *Spirogyra biformis* Jao.
Fig. 69. *Spirogyra szechwanensis* Jao.
Figs. 70, 71. *Spirogyra nitida* (Dillwyn) Link.
Fig. 72. *Spirogyra elliptica* Jao, sp. nov.

Plate VII



PLATE VII

General Views $\times 302$; Separate Spore Details $\times 630$

Fig. 73. *Spirogyra obovata* Jao, sp. nov.

Figs. 74, 75. *Spirogyra subpapulata* Jao, sp. nov. Figure 75, showing one zygospore and two aplanospores.

Figs 76—78. *Spirogyra papulata* Jao.

Figs. 79, 80. *Spirogyra subcylindrospora* Jao.

Figs. 81—83. *Spirogyra rhizobrachialis* Jao. Figure 82, a vegetative cell, with a rhizoid-shaped attachment.

Plate VIII

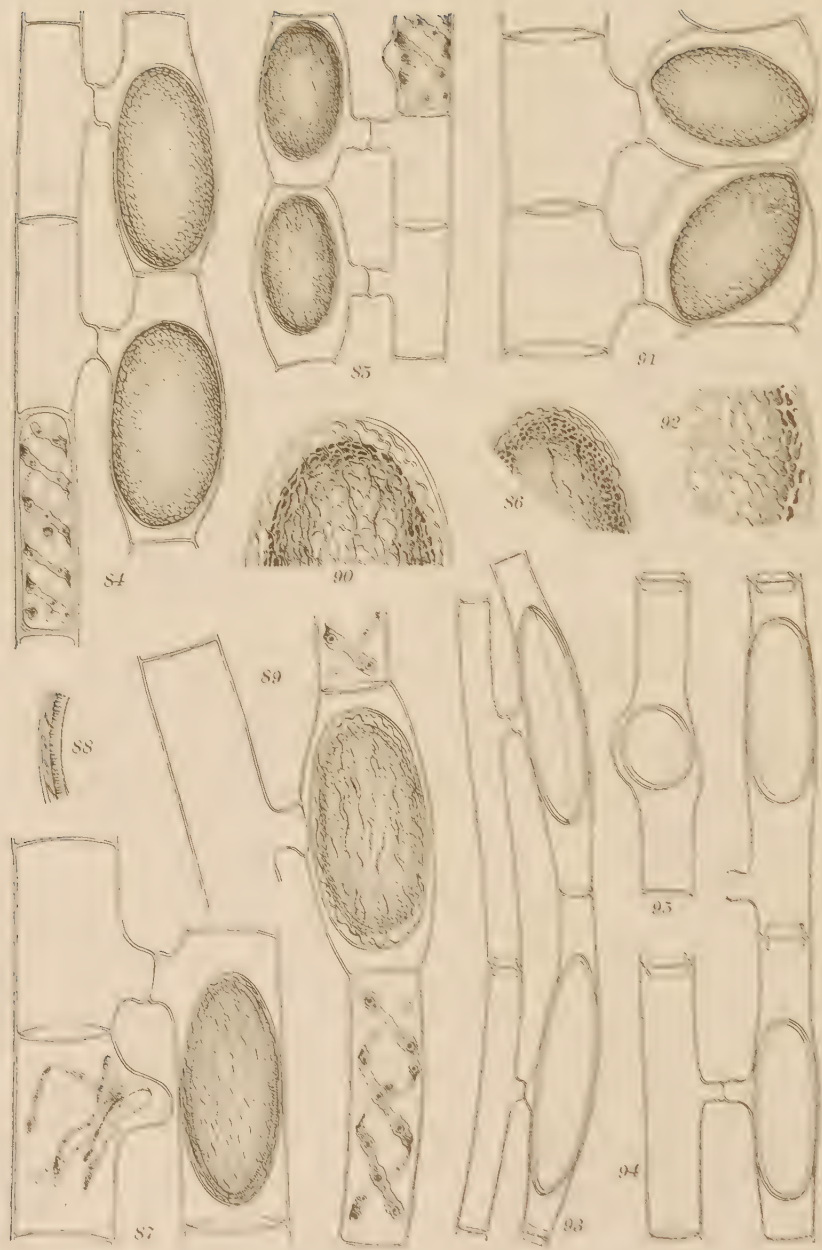


PLATE VIII

General Views $\times 302$; Separate Spore Details $\times 630$ Fig. 84. *Spirogyra dictyospora* Jao, sp. nov.Figs. 85, 86. *Spirogyra chungkingensis* Jao.Figs. 87, 88. *Spirogyra quadrilaminata* Jao. Figure 88, part of the spore wall in section.Figs. 89, 90. *Spirogyra corrugata* Transeau.Figs. 91, 92. *Spirogyra pulchrifigurata* Jao.Fig. 93. *Spirogyra arta* Jao, sp. nov.Figs. 94, 95. *Spirogyra Weheri* Kützing. Figure 95, aplanospore.

Plate IX

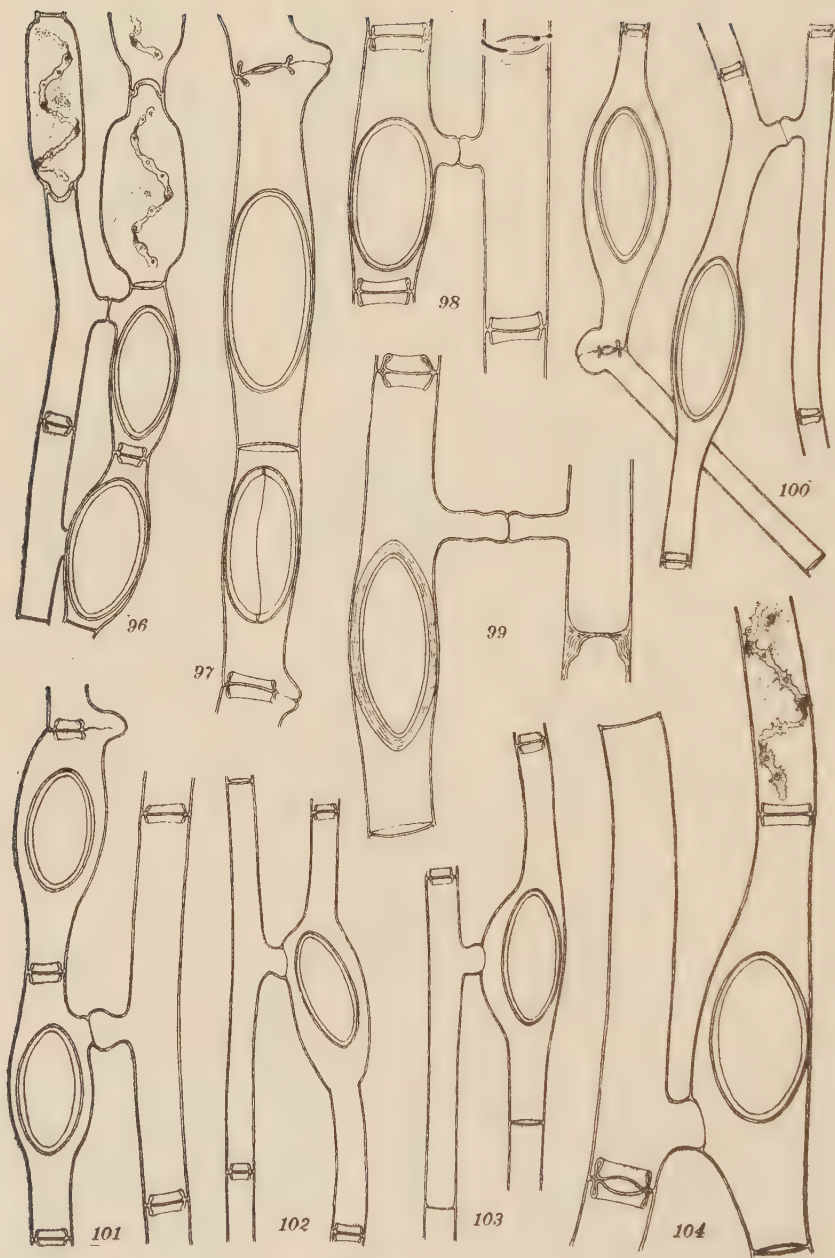


PLATE IX

All Figures $\times 302$

- Fig. 96. *Spirogyra tumida* Jao, sp. nov.
Figs. 97, 98. *Spirogyra semionnata* Jao, sp. nov.
Fig. 99. *Spirogyra lamellosa* Jao, sp. nov.
Fig. 100. *Spirogyra tenuissima* (Hassall) Kützing.
Fig. 101. *Spirogyra inflata* (Vaucher) Rabenhorst.
Fig. 102. *Spirogyra cylindrica* Czurda.
Fig. 103. *Spirogyra pseudospreeiana* Jao, sp. nov.
Fig. 104. *Spirogyra hopeiensis* Jao, sp. nov.

Plate X

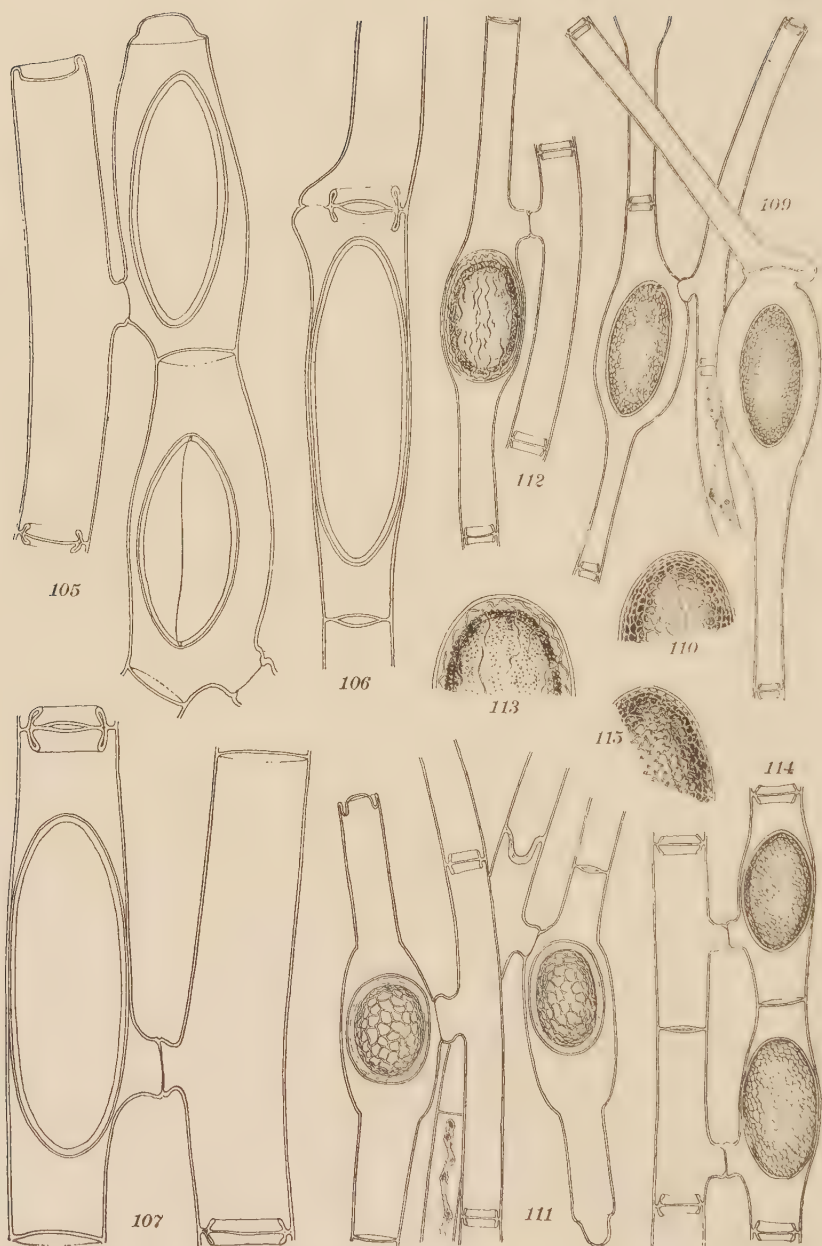


PLATE X

General Views $\times 302$; Separate Spore Details $\times 630$

- Fig. 105. *Spirogyra Chuniae* Jao.
Fig. 106. *Spirogyra Hassallii* (Jenner) Petit.
Fig. 107. *Spirogyra Transeauiana* Jao.
Figs. 108—110. *Spirogyra foveolata* (Skuja) Czurda.
Fig. 111. *Spirogyra laxistrata* Jao, sp. nov.
Figs. 112, 113. *Spirogyra microgranulata* Jao, sp. nov.
Figs. 114, 115. *Spirogyra dentireticulata* Jao, sp. nov.

Plate XI

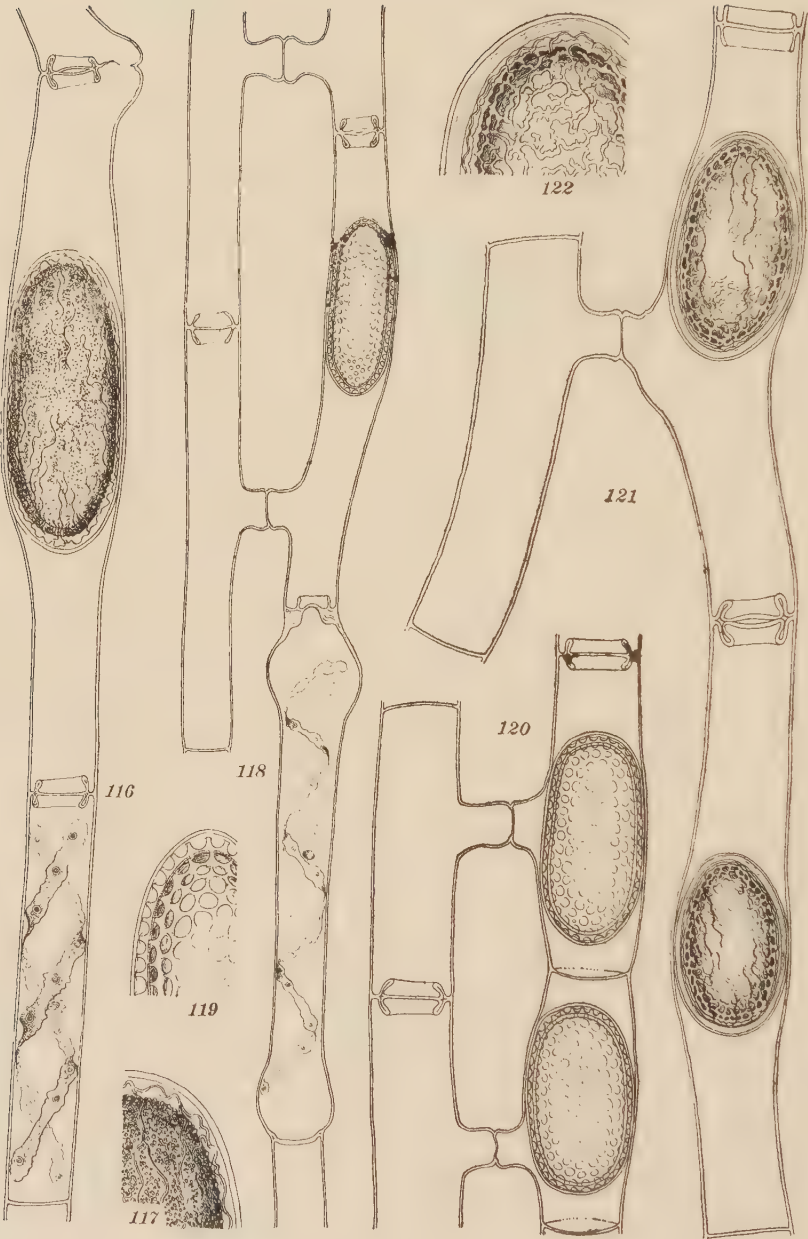


PLATE XI

General Views $\times 302$; Separate Spore Details $\times 630$ Figs. 116, 117. *Spirogyra granulata* Jao, sp. nov.Figs. 118, 119. *Spirogyra venusta* Jao, sp. nov.Fig. 120. *Spirogyra Cleveana* Transeau.Figs. 121, 122. *Spirogyra quinquilaminata* Jao, sp. nov.

Plate XII

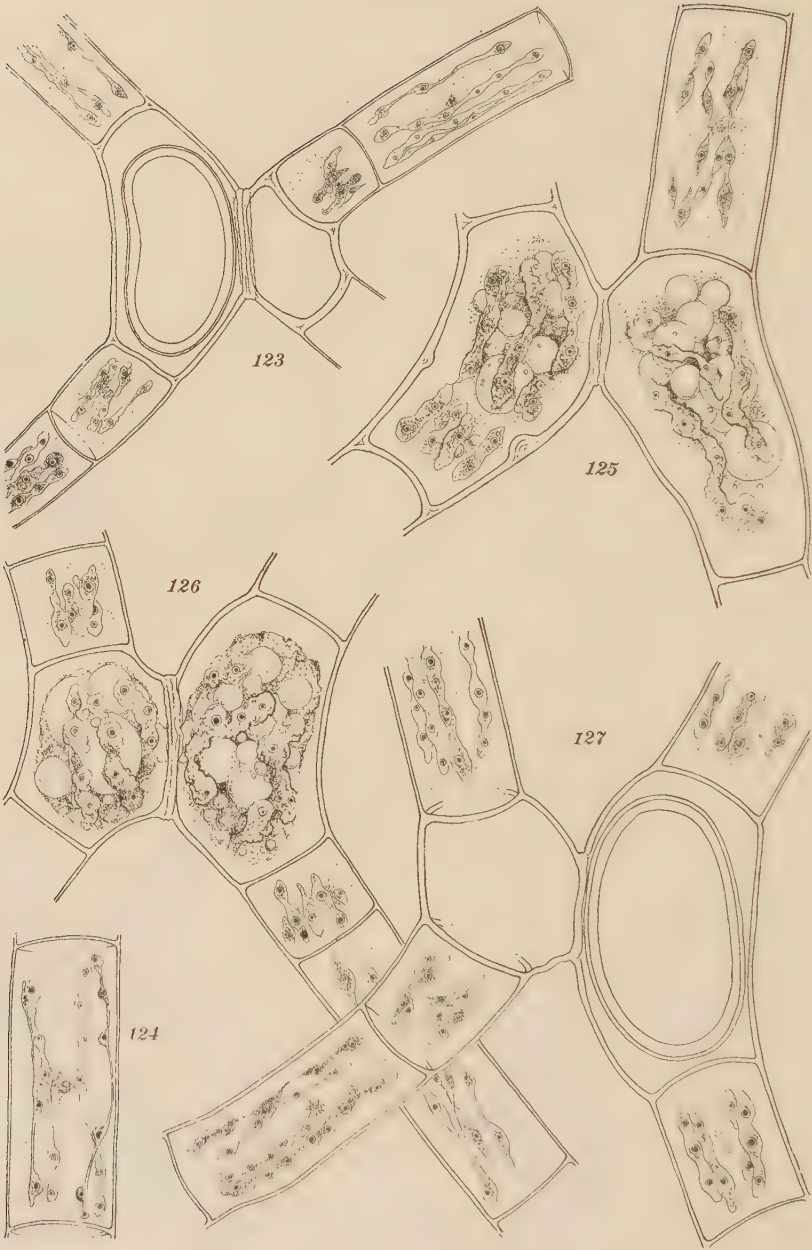


PLATE XII

All Figures $\times 302$

Fig. 123. *Sirogonium sticticum* (Engl. Bot.) Kützing.

Figs. 124—127. *Sirogonium sticticum* (Engl. Bot.) Kützing var. *megasporum* Jao, var. nov. Figure 124, vegetative cell containing the typical chromatophores in both face and edge views; Figure 125, early conjugating filaments, showing the "progametangia"; the left cell just beginning to form the cross wall between the gametangium and short sterile cell, in which the chromatophores have been divided into two sets and contain numerous large oil globules; Figure 126, young conjugating filaments, showing each "progametangium" have been divided into two cells, gametangium and sterile cell, and a visible cytoplasmic connection has been established between the young gametes; Figure 127, mature conjugating filaments with a mature zygospore.

